Togetherness in the Household*

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Abstract

Spending time together with a spouse is a major gain from marriage. We extend the classical collective model of the household to allow for togetherness between spouses. Togetherness takes the form of joint leisure and joint care for children, and naturally requires that spouses synchronize their schedules to be physically together at the same time. We provide a nonparametric characterization of togetherness that allows us to recover joint childcare separately from joint leisure, both rarely observed in the data. Using a survey of Dutch households, our model explains time allocation and consumption patterns substantially better than the classical model. Parents spend on average between 3.6 and 11.1 hours per week on joint childcare, representing up to 84% of the total childcare of one parent. Households are willing to pay €1.5 per hour -12.5% of the average wage- to convert private leisure to joint leisure, and €2.5 per hour to convert private childcare to joint childcare. Our results suggest that togetherness is an important component of household time use despite it being relatively overlooked in the economics literature.

Keywords: Joint leisure, joint childcare, private time use, collective model, irregular work, family labor supply, revealed preferences, LISS.

JEL classification: D11, D12, D13, J16, J22.

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1 Introduction

This paper studies how couples with children allocate their time across paid work, leisure, and childcare. A distinguishing feature is our focus on togetherness: we divide the time each spouse spends on leisure or childcare to *private* (time spent alone) and *joint* (time spent together). In doing so, we admit that togetherness naturally requires spouses to synchronize their schedules so as to be physically together at the same time. We provide the first nonparametric characterization of togetherness which, among other things, allows us to recover bounds on joint childcare separately from joint leisure - both rarely observed in the data. We then quantify the value of togetherness among Dutch households, we find it substantial, and we conclude that togetherness is an important component of household time use despite it being relatively overlooked in the economics literature.

Togetherness. Spending time together with a partner is a major source of gain from marriage (e.g. Becker, 1973; Hamermesh, 2000). However, with the exception of Fong and Zhang (2001) and Browning et al. (2018), models of household time use typically abstract from togetherness; as a result, we know very little about how households value togetherness, what benefits and costs it accrues, or how it interacts with other time uses. Addressing these points is precisely our main goal.

We develop a theoretical model for household time use and consumption in which leisure and childcare comprise activities that spouses can carry out privately or jointly. Private activities are carried out by each spouse alone while joint activities are carried out simultaneously and together by both. For example, private leisure may include a lone stroll in the park while joint leisure may include a night out together at the movies. Private childcare may involve feeding a baby or tutoring a young schoolchild while joint childcare may involve both parents playing together with their child.[1]

Togetherness has benefits and costs. Joint leisure may be desirable by spouses on the grounds of companionship but may entail the loss of flexibility in the labor market. Consider a household in which the husband works in the morning/afternoon but the wife, perhaps due to the nature of her job, works in the evening/night (e.g. a doctor doing certain night shifts). This household likely enjoys less togetherness than another one in which both spouses work simultaneously. Togetherness requires synchronization of work schedules which may be impossible without restricting one's flexibility at work and possibly reducing her earnings. An important conjecture therefore is that togetherness cannot be fully studied without also considering the *timing* of market work. Similarly, joint childcare may be beneficial to children (e.g. on child developmental grounds) but may *also* entail the loss of benefits from specialization in the household. Children typically

[1] Feeding a baby or tutoring a schoolchild may be carried out also jointly. These examples are offered to motivate ideas and their categorization as private or joint is not crucial for our analysis.

need active attendance for a given amount of time, say κ hours, which usually requires only one adult. Suppose that each parent has $\kappa/2$ hours available for childcare. If both supply it privately, they supply κ in total. If they supply it jointly, they only offer $\kappa/2$ while for the remaining time care must be provided by another, perhaps costly, caregiver.

Model. We start from a collective labor supply model in the spirit of Chiappori (1988). The collective model provides a flexible yet tractable description of household behavior. Father, mother and children are characterized by different utility functions and the degree of caring of parents for children may vary across households. The main assumption is that the outcome of the decision-making process is Pareto efficient.

Each parent values own private leisure as well as leisure jointly with the spouse. Children value each parent's private childcare as well as joint childcare. We focus on childcare as the main type of household work because parental involvement with children has important consequences for child development.[2] We do not restrict the way private and joint times enter utilities, thus we associate each such time use with, possibly, a different marginal effect. In this way we give joint times the possibility to yield marginal utility that differs from that of their private counterparts.

We capture the possibility that togetherness incurs a loss of flexibility at work by introducing different work schedules and by giving spouses a choice over them as well as over their overall working hours. Specifically, we admit that a typical working week consists of a conventional *7 am* to *6 pm Monday* to *Friday* window (which we call regular time) and a less conventional one with early morning, late evening, night, and weekend shifts (which we call *ir*regular time). We allow spouses to choose the amount of work in *each* time window, regular or irregular, thereby partially endogenizing the timing of market work. Finally, we assume that the precise timing of market work in the *irregular* window is determined by the employer rather than the worker herself. In line with Mas and Pallais (2017) workers have no control over the timing of *irregular* work, thus making synchronization of such work between spouses hard or impossible. Togetherness requires synchronization, therefore it limits a worker's opportunity to work within the irregular window and decreases her flexibility in the labor market.

We capture the possibility that togetherness incurs the loss of benefits of specialization in the household by introducing mandatory childcare over a certain amount of time. This reflects the need of young children for continuous attention and generalizes easily to other non-market tasks. Childcare can be provided by parents or other caregivers.

[2]The impact of parental time with children on child development has been studied extensively, see e.g. Cunha et al. (2010) and previous work, or Del Boca et al. (2014). These studies do not consider joint parental time. Del Boca et al. (2014) estimate, however, a complementary relationship between (private by assumption) parental childcare in child development. A special case of such complementarity is joint childcare in our paper. Nevertheless, modeling joint childcare here does not rule out traditional complementarities between private parental childcare.

Togetherness, however, requires that parents themselves care for their child jointly, thus limiting their capacity to specialize in the provision of this service. Our model allows us to monetize both *forgone specialization* and *forgone flexibility* by means of forgone earnings, in a way that will be made clear subsequently.

Implementation based on revealed preference theory. We derive a nonparametric characterization of togetherness and establish testable necessary and sufficient conditions for data consistency with collective rationality. We can implement these conditions even if only total leisure or total childcare are available per spouse, i.e. not their distinction to private and joint. Our approach fits in the literature on revealed preference characterizations of the collective model by Cherchye et al. (2007, 2009, 2011). We apply our test to time use and consumption data from the Longitudinal Internet Studies for the Social sciences (LISS) in the Netherlands. We use cross-sectional variation in wages and we allow for general heterogeneity across groups of households.

Our nonparametric approach offers three main advantages. First, it allows us to test consistency in a robust way, without resorting to parametric form assumptions. Any such assumption would inevitably restrict how togetherness interacts with other choices or how it accrues utility to household members. Given that togetherness is still largely understudied, we feel it is overly restrictive to discipline it through specific functional forms.[3] Second, it allows us to bound the fraction of time that spouses spend jointly on leisure or childcare. This is appealing because joint time is rarely observed in the data. Third, it yields global identification results.

Contribution & results. We offer four main contributions. First, we extend the classical collective model to allow for togetherness in the form of joint leisure and, separately, joint childcare. The closest paper to ours, Browning et al. (2018), estimates a collective model with joint leisure. Their main goal is to investigate the substitutability between private and joint leisure. Using Danish data on both types of leisure and a flexible parametric specification for utility, they find little substitution in practice. Unlike Browning et al. (2018), we consider various dimensions of togetherness: between two spouses (joint leisure), between parent and child (private childcare), and between both parents and child (joint childcare). Moreover, we admit that togetherness requires synchronization of time schedules and we explicitly model this.[4] Therefore, we let household members determine the amount of market work as well as, in part, the timing of it. We formalize the gains and costs of joint leisure and childcare relative to their private counterparts and we allow the value of togetherness to differ from that of private time. This is because togetherness

[3]For example, Browning et al. (2018) assume separability between leisure time and household expenditure, often rejected in the data (e.g. Blundell et al., 2016). Our approach naturally relaxes this.

[4]There is empirical evidence that couples synchronize their work (e.g. Sullivan, 1996; Hallberg, 2003).

in our model is naturally associated with forgone specialization and forgone flexibility that Browning et al. (2018) abstract from.

Second, we provide a nonparametric characterization of togetherness. To the best of our knowledge, this is the first paper to do so. This exercise is theoretically appealing for reasons explained above but also relevant in practice. We find that our model explains time use and consumption data substantially better than the classical collective model that does not distinguish between private and joint times (69% versus 6% pass rates).

Third, we show set-identification separately of joint leisure and joint childcare when, as is typically the case, only total leisure or total childcare are available per spouse. While Fong and Zhang (2001) provide original identification results for joint leisure, we extend identification to joint childcare too. In practice, we observe joint leisure in our data so we only estimate bounds on joint childcare. Our method produces informative bounds: parents spend on average between 3.6 and 11.1 hours per week on joint childcare, representing up to 84% of the total childcare of one parent. This result is useful to policy when interest lies in both the amount and the quality of childcare.

Fourth, we quantify the value of togetherness: we compute the household's willingness to pay to swap one unit of private time by each spouse with one unit of joint time. On average, households pay €1.47 per hour -12.5% of the average wage- to convert private leisure to joint, and €2.49 per hour -20% of the average wage- to convert private childcare to joint. Joint childcare is more expensive because it entails the loss of flexibility in the labor market *and* specialization in the household. So if parents choose joint childcare it must be because they value it relatively more highly. Furthermore, our results suggest that women are the likeliest to forgo work flexibility in order to increase togetherness even if they have the same preferences for togetherness as men. It is typically less costly for women to do so given the partners' specific work patterns; when this is true, households also value togetherness more highly. Forgone flexibility then reduces women's earnings and introduces a gender wage gap even if men and women previously received the same salary for the same job. This is in line with Goldin (2014)'s argument that the gender wage gap would be lower if women were as flexible as men in their work schedules.

Related literature. Since Gary Becker's treatise on the family (Becker, 1973, 1981), household economics study decisions made in the family.[5] Our model falls in the collective approach: formalized in Apps and Rees (1988) and Chiappori (1988, 1992), this approach respects methodological individualism but remains empirically tractable. While this literature has also studied home production (Chiappori, 1997) and public goods (Blundell et al., 2005), it is scarce in studying time use.[6] A distinct literature on the economics of

[5] Extensive recent reviews of this literature are Donni and Chiappori (2011), Chiappori and Mazzocco (2017), and Greenwood et al. (2017).

[6] Cherchye et al. (2012), Lise and Yamada (2019), Browning and Gørtz (2012) and Browning et al. (2018) are notable exceptions. Only the fourth paper studies joint time (leisure).

time use, inaugurated by Becker (1965), is concerned with the allocation of time across work and non-work activities. Recent research defines and measures important concepts such as demand for time (Hamermesh and Biddle, 2018), the timing of work (Hamermesh, 1999), time strain (Hamermesh and Lee, 2007) and more. Our paper partly bridges the two strands of literature: along with modeling private and joint time in the household, we address Hamermesh (1998)'s critique that most theories and empirical analyses of time focus on the duration of a given activity rather than also its timing.

Our focus on togetherness should not be surprising. There has long been evidence that couples like spending time together, be it for leisure or work (Sullivan, 1996; Qi et al., 2017). Workers use well-defined breaks -such as weekends- in order to synchronize schedules within the family (Brown et al., 2011). However, synchronization is not always possible when employers control the timing of work. Sociological studies by Cousins and Tang (2004) and Ruppanner and Maume (2016) show that employees in countries with shorter working hours report more work-family conflict. It turns out that the benefits of shorter workweeks quickly evaporate when associated with more variability/less predictability in hours worked (e.g. Voorpostel et al., 2010; The Economist, 2014). Mas and Pallais (2017) found that employees are unwilling to pay for more control over the timing of work, when the default option is to work regular hours. By contrast, they are willing to pay substantially to avoid their employer fixing the timing of work outside conventional hours. This is consistent with demand for togetherness which, as we argued above and develop subsequently, requires that spouses synchronize their work schedules.

Our interest in joint childcare is warranted by the implications it has for child development. Joint care implies a higher concentration of adults around the child (Folbre et al., 2005) and the child may benefit from spending time together with both parents. Togetherness may enhance the sense of closeness (Crouter et al., 2004) and facilitate communication within the family (Bronfenbrenner, 1979).[7] Communication between spouses could also improve their parenting skills. However, the presence of children in practice often decreases parental time synchronization (van Klaveren and van den Brink, 2007; Barnet-Verzat et al., 2011; Bryan and Sevilla, 2017), perhaps due to the pressure childcare puts on parents' time and money budgets (Presser, 1994). This is why it is important to study joint leisure alongside parents' work and childcare duties, as we do here.

The rest of the paper is organized as follows. Section 2 provides motivating empirical facts on leisure, work schedules, and childcare. Section 3 presents our model and describes optimal behavior. Section 4 provides the nonparametric characterization and discusses identification. We present our main results in section 5 and we conclude in section 6.

[7]Like Offer (2013) and Milkie et al. (2015), Crouter et al. (2004) mainly focused on adolescents rather than young children. Milkie et al. (2015) found, for instance, that family time improved adolescents' self-concept and decreased drug use, and that 'active' family time decreased behavioral problems and improved self-concept and math performance.

2 Empirical grounds

The main data we use throughout the paper come from the Longitudinal Internet Studies for the Social sciences (LISS) in the Netherlands (CentERdata, 2012). The LISS started in 2007 tracking a nationally representative sample of approximately 4500 households with the aim to gather information on their members' life course and living conditions. The core study of the panel repeats every year collecting data on household composition, members' incomes, employment, housing etc., similar to other major surveys such as the PSID or the BHPS. In addition to the core study, researchers can propose additional questions to which participants respond online on up to a monthly basis. This feature makes the LISS attractive as it is rich on information spanning economic outcomes, time use, the timing of certain activities, and many more.[8]

We draw data from three waves, covering calendar years 2009, 2010, and 2012. We need information on household consumption and members' time use and this is consistently available only in those years (the first wave is described in Cherchye et al., 2012). Within each year we observe certain variables with monthly frequency (income, employment) but most other variables only once (consumption, time use). Therefore we have complete information at most in three points in time.

Our main sample includes married or permanently cohabiting couples with children up to 12 years old as, given our focus on childcare, it is unreasonable to admit families with older children. We further restrict this sample to households where both adult members participate in the labor market. While this introduces some selection (among couples with young children, 98% of men and 76% of women work), it is necessary to do so as our revealed preferences approach requires wages for both spouses. Our final sample includes 398 household/year observations. We present summary statistics in section 5.1 and additional details about the data and the sample selection in appendix A.

A unique feature of our data is that we observe the time each spouse spends on leisure activities. Therefore, unlike most other data, we do not have to calculate leisure as the remainder time after accounting for work and other tasks. Moreover, we directly observe the fraction of leisure that spouses spend together with one another, which is what we call joint leisure.[9] Figure 1 sorts the households in our sample with respect to aggregate leisure, namely the *sum* of spouses' total leisure times. Additionally it plots the *average* leisure between spouses, namely half the aggregate. Two points stand out. First, average

[8]Further information about the LISS as well as access to the data is available at www.lissdata.nl. Participating households without Internet access were provided a connection and, if needed, a computer.

[9]The leisure questions in the data are *How much time did you spend in the last seven days on leisure activities?* - which we use for total leisure of each spouse, and *You have indicated that you spent [the answer to the first question] on leisure time activities, in the seven days preceding today. Please indicate how much of that time you spent together with your partner?* - which we use for joint leisure. In case the spouses disagree on the amount of joint leisure, we use the minimum of their answers (see appendix A). Note that the questionnaires were administered in September/October and early December so we miss any potential seasonal patterns in leisure, for example due to summer holidays.

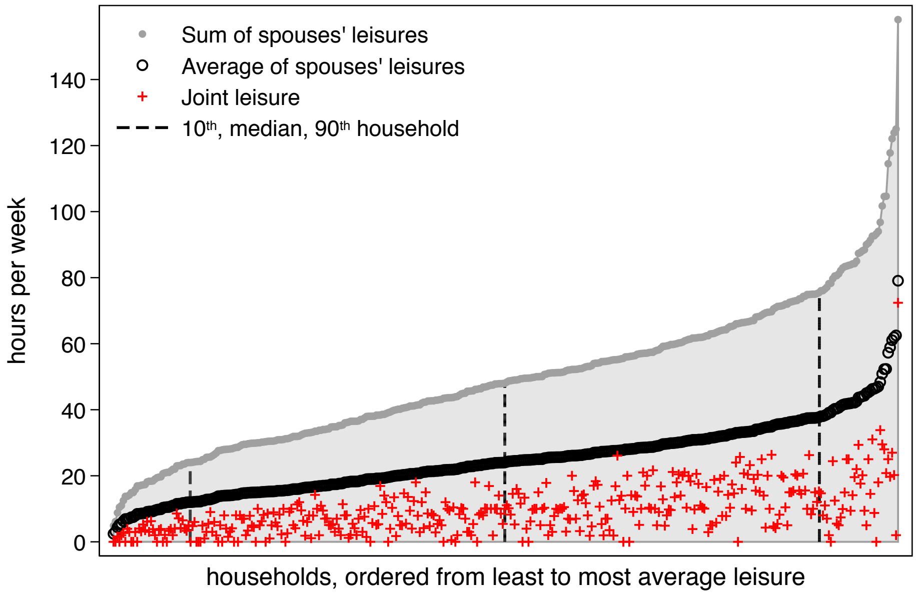

Figure 1 – Weekly leisure: aggregate, average, joint

leisure in the middle 80% of households is between 12 and 38 hours per week (24 for the median household). Second, most couples (91.7% of them) have some joint leisure. In the middle 80% of households this is between 1.5 and 20 hours per week, meaning that a large fraction of average leisure between spouses is actually joint leisure. As a result, adding up spouses' total leisures (top gray line in figure 1) overestimates how prevalent leisure is in a typical week as it double counts joint leisure.

Unlike joint leisure, we do not observe joint childcare. However, we do observe the time each spouse spends on childcare (which comprises private and joint childcare) and we plot it in figure 2. Three points stand out. First, while mothers are the main carer of young children, fathers too contribute to childcare quite substantially: the median mother supplies 20 weekly hours while the median father supplies 10.6. Second, only 0.5% of mothers and 2% of fathers do not provide any childcare at all. In the majority of households *both* parents supply strictly positive hours, which is a necessary condition for the existence of a joint component in childcare. Third, mothers' and fathers' hours are positively correlated. While there are several underlying structures that may generate this correlation, one of them is when a large part of parents' childcare is carried out jointly. Our model will help assess this claim.

While the evidence so far points to some demand for togetherness, togetherness is not possible without the couple being physically together at the same time. The spouses may differ in the number of hours they devote to market work as well as the timing of such work in a typical week. In figure 3 we plot the extent to which the spouses work irregular hours, namely outside the conventional *7 am* to *6 pm Monday* to *Friday* window

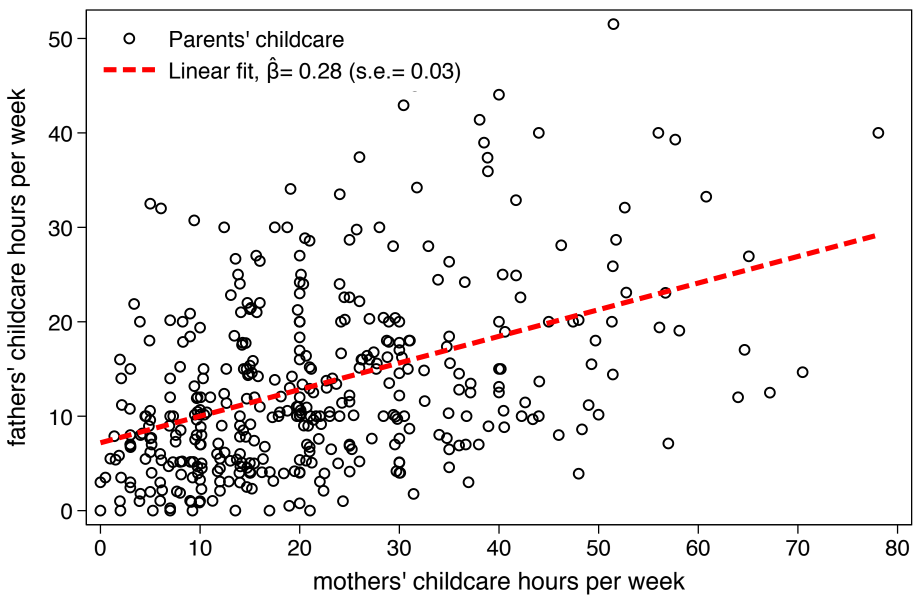

Figure 2 – Weekly childcare: mothers and fathers

such as evenings, nights, or weekends.[10] Two points stand out. First, a large fraction of individuals work some irregular hours: approximately 55% of men and 38% of women report doing so *sometimes* or *often*. Second, asynchronous work is prevalent between

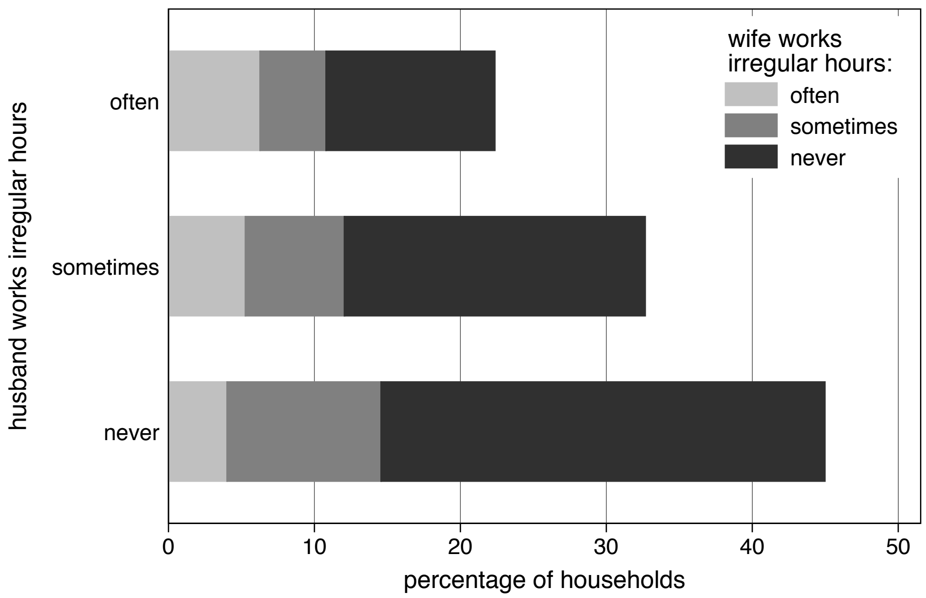

Figure 3 – Market work: irregular hours

[10]The timing of market work question is *Now follows a list of aspects that can characterize a job. Please indicate whether the following aspects are often, sometimes or never characteristic for your job. [...] Do you work irregular hours?* Other questions on the list include whether the job is tiring, physically demanding, mentally demanding etc. Another question is *Does your job often require you to work outside regular office hours, that is, during hours other than between 7 am and 6 pm?* More than 75% of the sample provides the same answers to both the first question and this one. We use data from the original question because, consistent with our model, it reflects the worker's *choice* for irregular work.

Table 1 – Descriptive statistics: leisure and childcare

	mean	median	10^{th} pct.	90^{th} pct.
leisure male	25.9	25.0	9.0	43.0
leisure female	23.6	21.0	8.9	41.4
joint leisure	9.5	8.2	1.5	20.0
childcare male	13.3	10.6	3.1	26.9
childcare female	21.7	20.0	5.1	41.7

Notes: The table reports the average, median, 10^{th} and 90^{th} percentiles of leisure and childcare. All statistics are calculated over 398 household/year observations. See appendix A for details on the sample and variable definitions.

spouses: in one third of households where the male spouse never works irregularly, the female spouse does so at least sometimes; in one half of households where the husband often works irregularly, the wife never does so. Even though the precise timing of work cannot be inferred in these data, the data are indicative of a large extent of misalignment between spouses' timing of market work. This misalignment matters for togetherness as it hampers the possibility the spouses spend time jointly. Our model allows for such misalignment enabling us to assess its implications for family time use.

Before introducing the model, we present descriptives for leisure and childcare (table 1)

Table 2 – Linear regressions: leisure and childcare

	leisure male	leisure female	joint leisure	childcare male	childcare female
leisure male		-0.04	0.18^{*}	-0.13^{*}	0.03
leisure female	-0.05		0.28^{*}	-0.02	-0.27^{*}
joint leisure	0.82^{*}	1.05^{*}		0.08	0.12
childcare male	-0.25^{*}	-0.03	0.04		0.39^{*}
childcare female	0.03	-0.24^{*}	0.03	0.21^{*}	
1[irregular work male]	0.97	0.11	-0.60	0.25	0.37
1[irregular work female]	-2.14	-1.27	-0.27	0.80	-1.16
wage male	0.20	0.05	-0.06	0.14	-0.14
wage female	-0.15	0.11	0.02	0.08	0.38^{*}
1[male $\leq$ 40 yrs]	0.15	0.51	-0.16	1.57	0.05
1[female $\leq$ 40 yrs]	1.05	-0.31	-0.26	-0.77	3.54^{+}
1[child 4-6 yrs]	-0.68	0.22	-0.16	-1.17	-3.97^{+}
1[child 7-12 yrs]	1.01	0.58	-0.94	-3.46^{*}	-8.48^{*}
constant	20.45^{*}	18.58^{*}	-1.54	9.96^{*}	20.93^{*}

Notes: $^{+}$ $p< 0.05$, * $p< 0.01$. The table reports coefficients from linear regressions of leisure and childcare on themselves and on male & female wages and indicator variables for whether a spouse works irregular hours *at least sometimes*, is up to 40 years old, or for children's age in two brackets (4 to 6; 7 to 12). All statistics are calculated over 398 household/year observations. In column four we report a coefficient on female childcare equal to 0.21. This differs from $\widehat{\beta} = 0.28$ reported in figure 2 because this table adds control variables. Results in logs are qualitatively and statistically similar even though we lose a few observations for which some time use is zero. See appendix A for details on the sample and variable definitions.

and coefficients from linear regressions on these variables, wages, and select demographics (table 2). While most coefficients have the expected sign, two points are of interest. First, joint leisure does not behave similarly to overall leisure. Childcare correlates positively with joint leisure but negatively with spouses' overall leisure. Interestingly, this can be explained by spouses specializing their childcare, with a negative correlation between joint childcare and joint leisure. Second, irregular work by either spouse is negatively correlated with joint leisure even though irregular work by the husband associates positively with spouses' overall leisure while irregular work by the wife associates negatively.

3 Collective model with private and joint time use

3.1 Model preliminaries

In the model a household consists of two adult members, subscripted by $m = \{1, 2\}$, and a number of young children. Each adult member, i.e. each spouse, is endowed with $\mathcal{T}_m$ units of time after sleep and personal care that are allocated to leisure L_m, childcare T_m, and market work H_m.[11] Therefore, each spouse has a time budget given by

$$L_m + T_m + H_m = \mathcal{T}_m. \tag{1}$$

Leisure and childcare comprise activities that spouses can carry out *privately* or *jointly*. Let l_m denote spouse m's private leisure and l_J denote joint leisure. Similarly, let t_m denote m's private childcare and t_J joint childcare. In total, spouse m spends

$$\begin{aligned} l_m + l_J &= L_m \\ t_m + t_J &= T_m \end{aligned} \tag{2}$$

time on leisure and childcare respectively. This distinction between private and joint time use is in the epicentre of our paper. With the exception of a limited number of surveys and time diaries, however, private and joint times are typically not observed separately. One of our contributions is to address precisely this: we provide restrictions that separate private from joint time use when all that is observed is their *sum*.

Market work is strictly private. The spouses, however, have a choice over the *amount* of hours H_m as well as the *timing* of such work within a day in a way that we define below. There are two reasons why we introduce (an element of) timing. First, the incidence of irregular work, strange hours (e.g. night shifts), or asynchronous work between spouses is empirically relevant (Hamermesh and Stancanelli, 2015, also figure 3) and has implications for family choices and welfare (Craig and Powell, 2012). Second, togetherness

[11] The spouses can have heterogeneous time endowments due to differences in the amount of sleep, personal care, or other uses of time that we abstract from such as household chores.

requires spouses to be physically together at the same time. If their work schedules are asynchronous, and this asynchronicity is driven by incentives or restrictions in the labor market, then their capacity to spend time jointly may be limited. Therefore the timing of market work is crucial for togetherness.

We operationalize timing as follows. We divide the working week into two zones: a *regular* working zone that falls within the conventional *7 am* to *6 pm Monday* to *Friday* window and an *irregular* one that occupies all other hours (i.e. evenings, nights, weekend). Each spouse chooses how much they work within each zone with h_m^R denoting m's regular hours (i.e. her labor supply in the regular zone) and h_m^I her irregular hours (i.e. her labor supply in the irregular zone) such that

$$h_m^R + h_m^I = H_m. \tag{3}$$

A regular hour of work pays a wage w_m while an irregular hour pays a wage $w_m + p_m$, i.e. it pays a premium p_m. We think of this premium as weakly positive in order to reflect the compensation a worker must receive for the inconvenience (defined formally in the next section) of working outside the conventional time zone. By allowing spouses to work over different time zones we capture the main conceptual restriction relevant to togetherness, namely that time cannot be joint unless spouses synchronize, i.e. unless they are physically together at the same time.

Each spouse has utility U_m over private and joint leisure, and parental consumption C_P, given by

$$U_m(l_m, l_J, C_P).$$

Children also have utility U_K which is a function of their parents' private childcare, joint childcare, and child consumption C_K, and is given by

$$U_K(t_1, t_2, t_J, C_K).$$[12]

Private and joint times enter separately in U_m and U_K so as to associate such time uses with *possibly* different marginal utilities. If togetherness yields benefits to the household over and above private leisure and private childcare, then our formulation allows for this while still retaining traditional complementarities between different time uses.

Finally, a standard budget constraint connects expenditure (parental consumption,

[12] We do not distinguish families with respect to the number of children they have, thus U_K captures utility of all children in the household combined. U_K can have two alternative interpretations. It may capture child utility as in Dunbar et al. (2013) but it may alternatively reflect child quality as in Del Boca et al. (2014). In the latter case, child quality is produced by a production function $F(\cdot)$ that takes parental childcare and child expenditure as inputs. In such case $U_K \equiv \widetilde{U}_K F$ where $\widetilde{U}_K$ captures parental preferences over child quality. The two interpretations are indistinguishable with data on parental childcare and child consumption alone.

child consumption, market childcare T_K) to non-labor income Y and earnings, given by

$$C_P + C_K + w_K T_K = Y + \sum_{m=1}^{2} w_m h_m^R + \sum_{m=1}^{2} (w_m + p_m) h_m^I. \tag{4}$$

As is typical, we treat the price of parental and child consumption as the numeraire while we price market childcare at w_K (for example, the wage of an external carer).[13]

3.2 Costs of togetherness

The potential benefits of togetherness stem from joint time having marginal utility that differs from that of private time, reflecting companionship, child developmental benefits, etc. Its costs pertain to *forgone flexibility* and *forgone specialization*.

Forgone flexibility. Forgone flexibility corresponds to the cost of togetherness overall, be it in the form of joint leisure or joint childcare. The idea in a nutshell is as follows: togetherness requires both spouses to be together at the same time. This is feasible if they synchronize their work schedules in such way so as to be away from market work at the same time. In an environment where irregular shifts pay a premium and their timing is rigid, synchronization *may* be impossible without restricting the flexibility of the worker and reducing her earnings.

More formally, togetherness requires to account for the *joint timing* of market work, something that the spouses' time budgets alone do not do. We make two conjectures:

- The spouses' regular working hours h_m^R always overlap as they take place within the fixed *7 am* to *6 pm Monday* to *Friday* window. This is not saying that the spouses work the same amount of regular hours: one may work less and another more. Nevertheless, the person who works less is at work *at the same time* when her partner also is. This automatically implies that the person who is at work *for longer* limits the maximum amount of joint time available to the couple.

- The spouses cannot synchronize their irregular hours h_m^I between them, therefore these hours never overlap. We think of the timing of irregular work as rigid, determined at short notice by industry or job rubric (e.g. a nurse having to do the occasional night shift). This makes it hard or impossible for spouses to synchronize these shifts between them,[14] therefore irregular work by *either* spouse limits the maximum amount of joint time available to them.

[13] We exclude market childcare T_K from children's utility U_K in order to simplify our nonparametric characterization in section 4. The exclusion effectively assumes that children's marginal utility of market childcare is zero, i.e. $\partial U_K / \partial T_K = 0$. Nevertheless, parents still purchase T_K because, as we show subsequently, children may require care at times when the parents cannot provide such care themselves.

[14] Irregular work is often associated with workers being on-call or generally unable to anticipate their precise work schedule (eg. Mas and Pallais, 2017, for the US), let alone coordinate such schedule with

Putting these conjectures together, the maximum amount of time the spouses can spend jointly (leisure and childcare) is given by

$$l_J + t_J \leq \mathcal{T}_m - \max\left\{h_1^R, h_2^R\right\} - h_1^I - h_2^I \tag{5}$$

and proven in appendix B.1. Maximum togetherness equals total time $\mathcal{T}_m$ (by construction the minimum $\mathcal{T}_m$ in the couple) but is reduced by the amount and type of spouses' market work. The more they work, the less time they can spend together. An increase in regular hours by the person who works the most reduces maximum togetherness one-to-one; an increase by the spouse who works the least leaves it unchanged. By contrast, an increase in irregular hours by either spouse reduces maximum togetherness one-to-one. The converse also holds: an increase in togetherness beyond the upper bound above requires at least one spouse to give up part of her market hours, thus forgo labor earnings.

Two remarks are in order. First, a household that uses its maximum joint time (i.e. condition (5) binds) may have *additional* togetherness only if one or both spouses give up part of their market work. Although both types of work enter this boundary condition, irregular work tightens togetherness *the most* because of our assumption that spouses cannot synchronize there. This facilitates the empirical implementation of our model because, as we show subsequently, the premium of irregular work conveniently disciplines the associated forgone flexibility. Second, our model allows that part of market work overlaps between spouses and another, empirically smaller, part does not. Thus, it offers a generalization to an environment where hours strictly only overlap *or* strictly do not.

Forgone specialization. Forgone specialization is the cost of joint childcare. The idea in a nutshell is as follows: keeping leisure and market work constant, the spouses must sacrifice one unit of private childcare t_1 *and* one unit of private childcare t_2 in order to obtain one more unit of joint childcare t_J. So the household must forgo two units of private childcare in total to gain only one unit of joint childcare.

More formally, specialization in our context is associated with the presence of young children in the household who require attention and care for $\mathcal{T}_K$ units of time. This gives rise to a childcare constraint that parents face, given by

$$\sum_{m=1}^{2} t_m + t_J + T_K = \mathcal{T}_K. \tag{6}$$

their spouse. It is, however, statistically possible that irregular work sometimes overlaps between spouses. There are 113 weekly hours outside the *7 am* to *6 pm Monday* to *Friday* window. The male spouse in our estimation sample works on average 8.26 irregular hours per week while the female spouse works 3.13 (table 3). Therefore, there is only a 8.26/113 ≈ 7.3% probability these hours overlap, assuming they are consecutive and mutually independent. Yet, as the spouses are unable to anticipate their schedules, they are also unable to anticipate a coincidental overlap in their irregular hours. Such overlap does not enable them to plan joint activities -such as city trips- in their unexpectedly overlapping non-work time.

The constraint enumerates all available childcare sources and reflects the loss of benefits of specialization when parents engage in joint childcare. Suppose each spouse has $\mathcal{T}_K/2$ hours available to look after children. If the spouses specialize and supply childcare privately, they supply $\mathcal{T}_K$ hours in total. But if they look after them simultaneously and together, they supply $t_J = \mathcal{T}_K/2$ hours only. Even if such joint hours may be more pleasant to parents and more beneficial to children, the spouses need additional childcare to fill the gap of the remaining $\mathcal{T}_K/2$ hours. Having exhausted their own hypothetical hours, they must source such childcare elsewhere, possibly on the costly market (i.e. T_K). Forgone specialization thus incurs a cost of t_J hours that can be monetized in different ways, for example at the price of market childcare.

Three remarks are in order here. First, childcare constraint (6) stems solely from admitting that children require active care for $\mathcal{T}_K$ hours and it does not reflect a children's time budget. We allow $\mathcal{T}_K$ to be different from $\mathcal{T}_m$ because children do not typically require parental or market care during the entire day: grandparents may also contribute to childcare, older children spend time in school or with friends etc. We thus consider $\mathcal{T}_K$ as the remaining time children require care for, net of all these other times.[15] Second, the childcare constraint in an environment where togetherness is *not* explicitly modeled becomes $\sum_{m=1}^{2} T_m + T_K = \mathcal{T}_K$; this double-counts the time spent jointly and overestimates the amount of time for which children receive parental attention. Our constraint (6) is nested within this latter constraint only if $t_J = 0$; otherwise it improves over it by correctly counting private and joint childcare separately. Third, we have purposefully introduced the costs of togetherness prior to showing the household problem in order to highlight that such costs are mostly accounting identities independent of the decision process in the household.

3.3 Household problem and optimal time allocation

The household maximizes a weighted sum of the spouses' respective utilities in the traditional collective spirit of Chiappori (1988, 1992) and Blundell et al. (2005). It chooses $\mathcal{C} = \{l_1,\ l_2,\ l_J,\ t_1,\ t_2,\ t_J,\ h_1^R,\ h_2^R,\ h_1^I,\ h_2^I,\ C_P,\ C_K,\ T_K\}$ in order to

$$\max_{\mathcal{C}}\ \mu_1 U_1(l_1, l_J, C_P) + \mu_2 U_2(l_2, l_J, C_P) \tag{P}$$

subject to

$$l_m + l_J + t_m + t_J + h_m^R + h_m^I = \mathcal{T}_m, \qquad m = \{1, 2\}$$

$$\mu_K: \qquad U_K(t_1, t_2, t_J, C_K) \geq u_K$$

[15] Interestingly, writing down the child's time budget precisely allows us to identify joint and private childcare by means of a system of 3 equations (two parental and one child's time budgets) in 3 unknowns $(t_J,\ t_1,\ t_2)$. Unfortunately this is not possible without detailed time diaries on family time use.

$$\lambda : \quad C_P + C_K + w_K T_K = Y + \sum_{m=1}^{2} w_m h_m^R + \sum_{m=1}^{2} (w_m + p_m) h_m^I$$

$$\tau_J : \quad l_J + t_J \leq \mathcal{T}_m - \max\left\{h_1^R, h_2^R\right\} - h_1^I - h_2^I$$

$$\tau_K : \quad \sum_{m=1}^{2} t_m + t_J + T_K = \mathcal{T}_K$$

and non-negativity constraints on consumption. The constraints, in the order they appear, are: the spouses' time budget (1) after plugging in the leisure/childcare and market hours identities (2) and (3); a lower bound on child utility (it ensures that parents care for their children's welfare); the money budget; the upper bound on togetherness (5); and the childcare constraint (6). The parameters on the left of the constraints are their respective shadow prices that appear subsequently in the discussion.

Consistent with the collective approach to household behavior, each spouse is associated with a utility weight or intra-household bargaining power μ_m.[16] This weight may depend on wages, demographics, or distribution factors (variables that affect bargaining power but not preferences or the budget set; Bourguignon et al., 2009). Here we suppress this dependence in order to ease the notation. Demographics will likely also affect the utility functions. We address both issues in the empirical implementation of our model.

Optimal time allocation. The household problem is convex so the first order conditions are necessary and sufficient. We present them explicitly below in order to characterize the benefits and costs of togetherness.

Let $U_{m,\mathfrak{c}}$ be the marginal utility of spouse m and $U_{K,\mathfrak{c}}$ the marginal utility of children, both with respect to variable $\mathfrak{c} \in \mathcal{C}$. Assuming $h_1^R > h_2^R$ without losing generality, and using the spousal time budgets in lieu of private leisure, the optimality conditions are

$$[l_J] : \quad \mu_1 U_{1,l_J} + \mu_2 U_{2,l_J} = \mu_1 U_{1,l_1} + \mu_2 U_{2,l_2} + \tau_J$$

$$[t_m] : \quad \mu_K U_{K,t_m} + \tau_K \leq \mu_m U_{m,l_m}$$

$$[t_J] : \quad \mu_K U_{K,t_J} + \tau_K \leq \mu_1 U_{1,l_1} + \mu_2 U_{2,l_2} + \tau_J$$

$$[h_1^R] : \quad \lambda w_1 = \mu_1 U_{1,l_1} + \tau_J$$

$$[h_2^R] : \quad \lambda w_2 = \mu_2 U_{2,l_2}$$

$$[h_m^I] : \quad \lambda (w_m + p_m) \leq \mu_m U_{m,l_m} + \tau_J$$

$$[C_P] : \quad \mu_1 U_{1,C_P} + \mu_2 U_{2,C_P} = \lambda$$

$$[C_K] : \quad \mu_K U_{K,C_K} = \lambda$$

$$[T_K] : \quad \tau_K = \lambda w_K.$$

The left hand side across all equations represents the marginal benefit of the respective

[16] The shadow price on the child's utility, μ_K, can be seen as the child's bargaining power in an environment where children act as decision makers. Here we have opted for a more conventional approach, namely that parents optimize on behalf of their children, i.e. they care for their children's welfare.

variable while the right hand side its marginal cost. To obtain these, we assume interior solution for leisure (95% of households have $l_m > 0$ and 91.7% have $l_J > 0$), regular hours (everyone in our sample works at least some regular hours), consumption (therefore the multipliers on the consumption non-negativity constraints become irrelevant) and market childcare (both parents are away at regular work simultaneously), but we allow for corners in the unobserved parental childcare variables as well as in irregular hours.

These equations describe the optimal family time allocation that satisfies the following features in equilibrium (all benefits and costs below are *marginal*):

- The benefit of joint leisure, captured by the weighted sum of the spouses' marginal utilities of l_J, equals the sum of two costs: first, the weighted sum of the spouses' marginal utilities of forgone private leisure; second, forgone flexibility when togetherness is at the upper bound defined by (5). In that case, forgone flexibility equals τ_J which we monetize subsequently. Rearranging we obtain $\tau_J = \mu_1(U_{1,l_J} - U_{1,l_1}) + \mu_2(U_{2,l_J} - U_{2,l_2})$: in equilibrium, forgone flexibility incurs a cost τ_J (forgone earnings), which equals the benefits of togetherness given by joint leisure's *additional* marginal utility *over* private leisure.

- The benefit of private childcare is given by the child's marginal utility of t_m and the savings τ_K the household achieves from sparing one unit of *market* childcare. The latter stems from the childcare constraint (6) and we monetize it subsequently. The cost of private childcare equals the marginal utility of forgone private leisure by the spouse who supplies care.

- The benefit of joint childcare is given by the child's marginal utility of t_J and the savings τ_K in market childcare. Its cost is: first, the weighted sum of *both* spouses' marginal utilities of forgone private leisure; second, the cost of forgone flexibility τ_J as above.

- The benefit of one regular hour of market work equals the wage rate w_m normalized by the price of consumption λ. Its cost is the marginal utility of forgone private leisure by whoever supplies such work and, in the case of spouse 1, the forgone benefits of togetherness given by τ_J. The latter arises because an additional hour of regular work by spouse 1 restricts togetherness by tightening constraint (5) (recall assumption $h_1^R > h_2^R$).

- The benefit of one irregular hour of market work equals the wage plus premium rate $w_m + p_m$ normalized by the price of consumption λ. Its cost is the marginal utility of forgone private leisure and the forgone benefits of togetherness given by τ_J. The latter is so because irregular work always restricts togetherness by tightening (5).

- The marginal utility of any type of consumption equals its price λ.

- Finally, the benefit τ_K of market childcare is equal to its cost given by the normalized unit price w_K. This monetizes the savings the household achieves from providing childcare internally.

There remains one last shadow price to characterize, namely τ_J or forgone flexibility when condition (5) binds. The simplest way to do this is when spouse 2 has *some* irregular hours. Then, a combination of the optimality conditions for h_2^R and h_2^I yields

$$\tau_J = \lambda p_2.$$

This indicates that joint time at the margin costs a (normalized) premium p_2. When maximum possible togetherness is tight, the household can enjoy more joint time if spouse 2 reduces her irregular work, that is if she gives up premium p_2. She does not have to give up the full $w_2 + p_2$ as she can still increase her regular hours while leaving (5) unaffected (up to $h_1^R = h_2^R$). This summarizes the core of our cost argument of togetherness when, due to industry or job rubric, the spouses cannot fully synchronize their market work: they must forgo earnings if they wish to spend time together.

Finally, rearranging the first order conditions for joint leisure and all types of childcare, we obtain

$$\mu_1(U_{1,l_J} - U_{1,l_1}) + \mu_2(U_{2,l_J} - U_{2,l_2}) = \lambda p_2 \tag{7}$$

$$\mu_K(U_{K,t_J} - U_{K,t_1} - U_{K,t_2}) = \lambda(p_2 + w_K). \tag{8}$$

Both equations describe the relationship, in equilibrium, between the benefits and costs of joint time *over* their private counterparts. The left hand side of (7) reflects the utility benefits joint leisure renders over private leisure. These benefits comes at the cost of forgone flexibility, on the right hand side, as the spouses reduce the extent of asynchronous work between them. This also provides a micro-foundation to the premium of irregular work: p_2 compensates for the inconvenience such work incurs by restricting togetherness in the household. The left hand side of (8) reflects the utility benefits to children when both parents engage with them rather than each one alone. These benefits comes at the cost, on the right hand side, of forgone flexibility (like above) and forgone specialization monetized at the unit price of market childcare. Analogous statements describe the optimal family time allocation when $h_1^R < h_2^R$.

4 Nonparametric identification of private and joint time use

We now formally introduce the notion of collective rationality with private and joint uses of time, and we provide a nonparametric characterization. This characterization allows us to test consistency of the model with the data without imposing specific functional forms on utility functions U_m and U_K. Moreover, it contains restrictions that enable us to recover private and joint times when only individual total times are available. Our nonparametric conditions fit in the revealed preferences literature in line with Afriat (1967), Diewert (1973) and Varian (1982). Cherchye et al. (2007, 2009, 2011) developed the revealed preference characterization of the collective labor supply model.

We start in 4.1 by introducing the baseline characterization of collective rationality with private and joint uses of time. This characterization makes a formal distinction between private and joint times but, unlike the model of section 3, does not introduce the togetherness upper bound (5) (reflecting forgone flexibility) and childcare constraint (6) (reflecting forgone specialization). In this simpler model the gains from joint and private times are equal in equilibrium. We show that this characterization still allows us to separate private from joint leisure. Subsequently, we develop in 4.2 the nonparametric characterization of collective rationality that is fully consistent with our model of section 3. This characterization allows us to separate both private from joint *leisure* and private from joint *childcare*. Finally, in 4.3 we discuss the implementation of such characterization in order to recover private and joint childcare in practice when only individual total childcare is available. We assume throughout that utility functions are well-behaved in the usual sense; no further restrictions are imposed on their functional form.[17]

Set-up. One of the main building blocks of revealed preference tests is the *Generalized Axiom of Revealed Preference* (GARP). The GARP constructs binary preference relationships between bundles of goods on the basis of information on the affordability of these bundles. Consider a data set $S = \{\mathbf{p}^{(v)}; \mathbf{q}^{(v)}\}_{v \in V}$ with $\mathbf{p}^{(v)} \in \mathbb{R}^{|N|}_{++}$ the vector of strictly positive prices and $\mathbf{q}^{(v)} \in \mathbb{R}^{|N|}_{+}$ the bundle of goods consumed in observation v. Let V represent the set of observations. Definition 1 provides a formal statement of the revealed preference relations that apply to S.

Definition 1 Consider a data set $S = \{\mathbf{p}^{(v)}; \mathbf{q}^{(v)}\}_{v \in V}$. The GARP asserts the existence of direct (R^0) and indirect preference (R) relations such that for all $v, s \in V$:

1. if $\mathbf{p}^{(v)\prime}\mathbf{q}^{(v)} \geq \mathbf{p}^{(v)\prime}\mathbf{q}^{(s)}$ then $\mathbf{q}^{(v)}\ R^0\ \mathbf{q}^{(s)}$;
2. if $\mathbf{q}^{(v)}\ R^0\ \mathbf{q}^{(s1)},\ \mathbf{q}^{(s1)}\ R^0\ \mathbf{q}^{(s2)}, \ldots,\ \mathbf{q}^{(sk)}\ R^0\ \mathbf{q}^{(s)}$ then $\mathbf{q}^{(v)}\ R\ \mathbf{q}^{(s)}$;

[17] That is, utility functions are continuous, concave and nonsatiated.

3. if $\mathbf{q}^{(v)}\ R\ \mathbf{q}^{(s)}$ then not $\mathbf{p}^{(s)\prime}\mathbf{q}^{(v)} < \mathbf{p}^{(s)\prime}\mathbf{q}^{(s)}$.

In words, the first condition states that $\mathbf{q}^{(v)}$ is directly revealed preferred over $\mathbf{q}^{(s)}$ if $\mathbf{q}^{(s)}$ was in the budget set when $\mathbf{q}^{(v)}$ was chosen. The second condition imposes transitivity. The last condition closes the revealed preference argument stating that if $\mathbf{q}^{(v)}$ is revealed preferred over $\mathbf{q}^{(s)}$ (i.e. at least as good as $\mathbf{q}^{(s)}$), it must be the case that $\mathbf{q}^{(v)}$ was not (strictly) affordable when $\mathbf{q}^{(s)}$ was chosen. Otherwise there existed an alternative bundle $\tilde{\mathbf{q}} \neq \mathbf{q}^{(s)}$ in budget set s that would have (strictly) improved this consumer's wellbeing.

4.1 Collective rationality

We first consider the simpler model that makes the explicit distinction between private and joint times but does not feature the togetherness upper bound (5) or childcare constraint (6). Definition 2 formally states our notion of collective rationality in this environment.

Definition 2 A group of households V is *collectively rational* if and only if there exist weights $\mu_m^{(v)}$, utility functions U_m and U_K, time variables $l_m^{(v)} + l_J^{(v)} = L_m^{(v)}$ and $t_m^{(v)} + t_J^{(v)} = T_m^{(v)}$, all for $m = \{1, 2\}$, such that each household solves problem (P) subject to time budget (1), the child utility lower bound $U_K \geq u_K$, and the money budget (4) with the right hand side given by $Y + \sum_{m=1}^{2} w_m H_m$.

For this and the next sections, we make the notation compact by defining $\delta_{m,\mathfrak{c}} = \mu_m U_{m,\mathfrak{c}}/\lambda$ and $\delta_{K,\mathfrak{c}} = \mu_K U_{K,\mathfrak{c}}/\lambda$. Dividing by λ and multiplying by μ eliminates sensitivity of our variables to the cardinality of utility functions and bargaining weights. For example, δ_{m,l_m} is spouse m's marginal willingness to pay for private leisure in her given household.

In the absence of constraints (5) and (6) the optimality conditions associated with joint leisure and childcare become

$$
\begin{aligned}
[l_J]: &\quad \delta_{1,l_J}^{(v)} + \delta_{2,l_J}^{(v)} = w_1^{(v)} + w_2^{(v)} \\
[t_m]: &\quad \delta_{K,t_m}^{(v)} = w_m^{(v)} \\
[t_J]: &\quad \delta_{K,t_J}^{(v)} = w_1^{(v)} + w_2^{(v)}
\end{aligned}
$$

while the optimality condition associated with private leisure is $\delta_{m,l_m}^{(v)} = w_m^{(v)}$.[18] It follows that, in equilibrium, the *total* gains from joint time equal the *total* gains from (both spouses') private times. Nonetheless, the *individual* gain from joint leisure, captured by $\delta_{m,l_J}^{(v)}$, may deviate from the *individual* gain from private leisure, captured by $\delta_{m,l_m}^{(v)}$. After all, joint leisure takes the form of a public good within the household and the corresponding individual willingness' to pay may vary.

[18]From here onwards, the optimality conditions appear *as if* we assume an interior solution; in reality our revealed preferences approach can easily deal with corners.

We combine the optimality conditions with concavity of the underlying utility functions to obtain that $S_m = \{w_m^{(v)},\ \delta_{m,l_J}^{(v)},\ \delta_{m,C_P}^{(v)};\ l_m^{(v)},\ l_J^{(v)},\ C_P^{(v)}\}_{v\in V}$ satisfy GARP as presented in Definition 1. Similarly, $S_K = \{w_1^{(v)},\ w_2^{(v)},\ 1;\ T_1^{(v)},\ T_2^{(v)},\ C_K^{(v)}\}_{v\in V}$ is also consistent with GARP. The latter claim is nontrivial; it follows from the childcare identity (2) and the optimality conditions associated with childcare. We refer to appendix B.2 for a detailed derivation. We are now ready to formalize the test for collective rationality.

Proposition 1 Consider a group of households V. The following statements are equivalent (proof in appendix B.2):

1. The households are *collectively rational.*

2. There exist shadow prices $\delta^{(v)}$ and leisure variables $l^{(v)}$ such that the following conditions hold for all v:

   (a) $\delta_{1,C_P}^{(v)} + \delta_{2,C_P}^{(v)} = 1$

   (b) $\delta_{1,l_J}^{(v)} + \delta_{2,l_J}^{(v)} = w_1^{(v)} + w_2^{(v)}$

   (c) $l_m^{(v)} + l_J^{(v)} = L_m^{(v)}$

   (d) S_1, S_2, S_K satisfy GARP with
   $S_m = \{w_m^{(v)},\ \delta_{m,l_J}^{(v)},\ \delta_{m,C_P}^{(v)};\ l_m^{(v)},\ l_J^{(v)},\ C_P^{(v)}\}_{v\in V}$
   $S_K = \{w_1^{(v)},\ w_2^{(v)},\ 1;\ T_1^{(v)},\ T_2^{(v)},\ C_K^{(v)}\}_{v\in V}$.

This mimics the revealed preference conditions for collective rationality derived by Cherchye et al. (2007). Statement *(a)* says that the individual willingness to pay for parental consumption sums up to the normalized consumption market price. This is the Lindahl-Bowen-Samuelson condition for the optimal provision of public goods, and stems from our assumption of Pareto efficiency. Statement *(b)* says that the individual willingness to pay for joint leisure sums up to $w_1^{(v)} + w_2^{(v)}$. Statement *(c)* is the leisure identity in (2). Finally, *(d)* states that the underlying data S_1, S_2, S_K satisfy the requirements of GARP.

Our main objective is to recover private and joint time uses, with a particular focus on joint childcare (which, unlike joint leisure, is unobserved in our data). In this respect, Proposition 1 has two important implications. On one hand, the test makes a distinction between private leisure and joint leisure. Joint leisure l_J is an argument in two GARP tests (S_1 and S_2) whereas l_m enters a single GARP test (S_m) only. The individual shadow price of l_m is observed but the individual shadow price of l_J is unknown. As indicated earlier, l_m and l_J represent a private (resp. public) good in the household, and Cherchye et al. (2012) have shown that the public nature of commodities within groups is testable.[19] On the other hand, this characterization of collective rationality does not

[19]Treating both time inputs l_1, l_2, l_J and prices δ_{1,l_1}, δ_{2,l_2}, δ_{m,l_J} as variables creates nonlinearities in the conditions. We refer to Cherchye et al. (2007) for a detailed discussion of the complexities associated with incorporating public goods in the revealed preference characterization of the collective model.

allow us to separate private childcare from joint childcare. The conditions in Proposition 1 are independent of the composition of T_m in terms of t_m and t_J. The underlying reason is that in this simplified environment (and in Definition 2) the gains from joint childcare equal the sum of gains from private childcare.[20]

4.2 Collective rationality with togetherness

We now introduce the nonparametric characterization of collective rationality considering all the constraints togetherness is associated with in our full model. Togetherness here may admit gains above and beyond the gains from spouses' private times. Household members are confronted with a trade-off between these gains and the costs associated with the upper bound on joint time (5) and childcare constraint (6). Definition 3 formally states our notion of collective rationality in this environment.

Definition 3 A group of households V is *collectively rational with togetherness* if and only if there exist weights $\mu_m^{(v)}$, utility functions U_m and U_K, time variables $l_m^{(v)} + l_J^{(v)} = L_m^{(v)}$ and $t_m^{(v)} + t_J^{(v)} = T_m^{(v)}$, all for $m = \{1, 2\}$, such that each household solves problem (P) as presented in section 3.3.

Let us now introduce the test of collective rationality with togetherness. Assume $h_1^R > h_2^R$ without losing generality.

Proposition 2 Consider a group of households V. The following statements are equivalent (proof in appendix B.3):

1. The households are *collectively rational with togetherness.*

2. Let $\begin{array}{l} \delta_{1,l_1}^{(v)} = w_1^{(v)} - p_2^{(v)} \\ \delta_{2,l_2}^{(v)} = w_2^{(v)} \end{array}$ and let $\begin{array}{l} \delta_{K,t_1}^{(v)} = w_1^{(v)} - p_2^{(v)} - w_K^{(v)} \\ \delta_{K,t_2}^{(v)} = w_2^{(v)} - w_K^{(v)} \\ \delta_{K,t_J}^{(v)} = w_1^{(v)} + w_2^{(v)} - w_K^{(v)} \end{array}$.

   There exist shadow prices $\delta^{(v)}$ and time variables $l^{(v)}$, $t^{(v)}$ such that the following conditions hold for all v:

   (a) $\delta_{1,C_P}^{(v)} + \delta_{2,C_P}^{(v)} = 1$

   (b) $\delta_{1,l_J}^{(v)} + \delta_{2,l_J}^{(v)} = w_1^{(v)} + w_2^{(v)}$

   (c) $l_m^{(v)} + l_J^{(v)} = L_m^{(v)}$ and $t_m^{(v)} + t_J^{(v)} = T_m^{(v)}$

   (d) $S_1, S_2, \tilde{S}_K$ satisfy *GARP* with

   $S_m = \{\delta_{m,l_m}^{(v)},\ \delta_{m,l_J}^{(v)},\ \delta_{m,C_P}^{(v)};\ l_m^{(v)},\ l_J^{(v)},\ C_P^{(v)}\}_{v\in V}$

   $\tilde{S}_K = \{\delta_{K,t_1}^{(v)}, \delta_{K,t_2}^{(v)}, \delta_{K,t_J}^{(v)}, 1;\ t_1^{(v)}, t_2^{(v)}, t_J^{(v)}, C_K^{(v)}\}_{v\in V}$.

[20] Similarly, this specification also excludes that *total* gains from joint leisure exceed the sum of gains from (two units of) private leisure. Identification of l_J thus rests solely on the idea that l_J is public and l_m is not. This hampers interpretation of l_J, as l_J could equally well capture private leisure activities with positive externalities within the household.

Statements *(a)-(d)* in Proposition 2 play a similar role as statements *(a)-(d)* in Proposition 1. Nonetheless, the shadow prices in Proposition 2 depend not only on wages w_m but also on premium p_2 and price of market childcare w_K. Recall from section 3 that the supplementary gain of joint leisure (over and beyond the gains from both spouses' private leisure) is precisely equal to the costs of forgone flexibility p_2 in equilibrium. Forgone earnings correspond to the premium of member 2 because 2 has the opportunity to increase togetherness in the household by replacing one irregular with one regular hour of market work (provided that $h_1^R > h_2^R$) at cost p_2. The willingness to pay of member 1 for private leisure is then the difference between the marginal value of his time (w_1) and the supplementary gain of joint leisure over private leisure (p_2).

The main distinguishing feature of Proposition 2, however, is the explicit distinction between t_m and t_J. The necessary and sufficient conditions for consistency with the model are no longer independent of the composition of T_m in terms of t_m and t_J. This is best reflected in statement *(d)*, which now requires that $\tilde{S}_K$ satisfies GARP. Different from S_K (Proposition 1), $\tilde{S}_K$ separates private childcare t_m from joint childcare t_J. Identification of t_m and t_J requires that δ_{K,t_J} differs from (i.e. exceeds) $\delta_{K,t_1} + \delta_{K,t_2}$. To this end, either the upper bound on joint time (5) or childcare constraint (6) must bind.[21] Econometricians who aim at recovering t_J within the framework of the collective labor supply model may therefore rely on one of these constraints.

4.3 Recovery of joint childcare in practice

The conditions in Proposition 2 provide a direct test of data consistency with our collective model with togetherness. In addition, the characterization allows us to non-parametrically recover bounds on the amount of joint childcare when only individual total childcare is observed.

Before moving on to our empirical application, it is necessary to reformulate the conditions in Proposition 2 in terms of a linear programming problem. We make two further adjustments. First, we capture the revealed preference relations of the GARP by means of binary variables. Second, we use data on private leisure l_m and joint leisure l_J in order to render our revealed preferences conditions linear. We can then formulate our conditions in terms of a mixed integer linear programming problem. The problem has a solution if and only if the data set is collectively rationalizable with togetherness.

Conditional on data consistency with our model, it is possible to recover bounds on unobserved joint childcare. By construction, joint childcare is always between 0 and the minimum *individual* total childcare, i.e. $t_J \in [0, \min\{T_1, T_2\}]$.[22] Our model allows us to sharpen these bounds. We start with a stylized example to fix ideas. Suppose

[21] We have set up our model so that each of these constraints has a monetary shadow price, i.e. w_K and p_2 respectively. If both constraints bind, then $\delta_{K,t_J} - \delta_{K,t_1} - \delta_{K,t_2} = w_K + p_2$.

[22] Joint childcare cannot exceed $\min\{T_1, T_2\}$ as it must not be larger than *either* parent's own childcare.

that we observe individual total childcare, wages, and money expenditures on children in two families A and B. Assume for simplicity that the wage premium is $p_m = 0$. The price of market childcare is $w_K = 3$. Furthermore, $w_m^{(A)} = 20$, $w_m^{(B)} = 10$, $T_m^{(A)} = 20$, $T_1^{(B)} = 20$, $T_2^{(B)} = 10$, $C_K^{(A)} = 75$ and $C_K^{(B)} = 200$. We first test data consistency with our two notions of collective rationality (Definitions 2 and 3). It turns out that the former concept is rejected by the data whereas the latter is not. In this case, a feasible solution to the conditions in Proposition 2 must satisfy $t_J^{(A)} + t_J^{(B)} \geq 18.33$. Appendix B.4 contains our formal argument.

Our example illustrates that the program associated with Proposition 2 generates informative bounds on t_J. To facilitate comparability across households, we recover the mean proportion of joint childcare $\alpha = (1/V)\sum_v t_J^{(v)}/\min\{T_1^{(v)}, T_2^{(v)}\}$ across households v rather than the sum $\sum_v t_J^{(v)}$. We minimize/maximize this mean proportion subject to the constraints in Proposition 2. In this way, we obtain a lower and upper bound on α for a given group of households. Finally, this nonparametric procedure makes it possible for the econometrician to tighten the bounds on α by adding more structure. One appealing set of restrictions is the following: $\alpha - \Delta \leq t_J^{(v)}/\min\{T_1^{(v)}, T_2^{(v)}\} \leq \alpha + \Delta$ (e.g. with $\Delta = 0.1$). This rules out that the proportion of joint childcare for a given household v deviates too far (e.g. more than 10 percentage points) from the *mean* proportion of joint childcare for that group of households to which v belongs.

5 Application

5.1 Empirical implementation

We use the results established in the previous section to test data consistency with our model, obtain bounds on unobserved joint childcare, and quantify the value households assign to togetherness. The empirical implementation requires data on individual total leisure, individual total childcare, regular and irregular hours of market work, hourly wages including the irregular work premium (all these for *each* spouse in the household), household-level parental and child consumption, and the unit cost of external childcare.[23] In addition, we use data on joint leisure; this is not strictly required but it helps us in the implementation of the revealed preferences conditions. All variables are observed in the LISS (see appendix A) except the regular and irregular hours of work, the irregular work premium, and the unit cost of market childcare. In this section we discuss how we obtain these variables and how we deal with heterogeneity across households. We also present summary statistics for our estimation sample.

[23] We do not use information on market childcare because the characterization of our model is independent of the precise level of T_K. This follows from the exclusion of T_K from children's utility U_K.

Regular and irregular hours, and prices. Although we do not separately observe work hours within or outside the *7 am* to *6 pm Monday* to *Friday* zone, we do observe frequency indicators for the incidence of irregular work. These indicators report whether a spouse works *often*, *sometimes*, or *never* outside this window and they form the basis for our motivating figure 3 in section 2. We translate this information by assigning to irregular hours 50% of a spouse's observed *total* market hours H_m in case irregular work occurs *often* and 25% in case it occurs *sometimes*. All remaining market hours are regular.

The premium for work at strange hours is typically regulated in the Netherlands by collective bargaining agreements. We exploit this fact to fix p_m at a constant proportion of a worker's wage, based on a study of Dutch collective bargaining agreements by Kuiper et al. (2014). The authors report that for the period of our study the average premium for work at night is 47% of the regular wage, while that for work in early morning or late evening is 25% and 42% respectively. Given that our data do not distinguish between night, early morning etc., we explore three different markups over regular wage, namely 50%, 25% and 0% (regular and irregular hours paid the same).[24]

The unit price of market childcare is approximately €6/hour for the years under consideration (Dutch Coalition for Community Schools, 2013). In practice, however, the Dutch government subsidizes childcare with poorer households receiving higher subsidies. Households themselves finance between 4% and 66% of the total cost of childcare, with an average of about 25% (Kok et al., 2011, page 9). We operationalize these facts by fixing w_K at 33% of the lowest salary in the household. In this way, we capture the fact that market childcare is cheaper for lower income households. The poorest household in our sample pays no more than €0.24/hour (a 4% of the market price), while the average household contributes just above €3/hour.[25]

Heterogeneity. There are two main ways to deal with cross-household heterogeneity within our framework. One is to apply our collective rationality tests on each household separately, given the longitudinal feature of our data and the fact that we typically observe a given household multiple times. This is the approach taken in Cosaert (2018) and allows for time-*invariant* heterogeneity across households (equivalent to household-specific preferences). Another is to pool similar households together and apply our tests on each group of households separately. This is the approach taken in Famulari (1995) and Cherchye and Vermeulen (2008) and allows for heterogeneity across groups while

[24]Regular wages are not observed either but they (w_m^R) can be recovered from the condition $h_m^R w_m^R + h_m^I (w_m^R + p_m) = w_m H_m$, with the right-hand side observed in the data.

[25]We make two further adjustments in p_m and w_K so that they are consistent with our equilibrium conditions. First, we fix $p_m = 0$ for the spouse who works the most regular hours. Our equilibrium conditions in this case make no distinction in the wage between regular and irregular hours. Second, we impose an upper bound on the sum of w_K and the premium of the spouse who works the least regular hours, i.e. $w_K + p_2 \leq w_1$ assuming $h_1^R > h_2^R$. Otherwise, the household is better off reducing 1's regular work and increasing togetherness as its value is higher than that of regular work; see also (5).

Table 3 – Sample summary statistics, weekly amounts

	male spouse		female spouse	
	mean	sd	mean	sd
age	41.08	5.61	38.66	5.41
1[university education or similar]	0.36	0.48	0.38	0.49
private leisure	16.49	12.32	14.16	11.44
childcare	13.30	9.82	21.67	14.36
regular work hours	32.86	9.57	20.47	9.24
irregular work hours	8.26	9.13	3.13	4.87
observed hourly wage (€)	12.37	5.02	11.64	4.40
	household			
	mean		sd	
age youngest child	5.77		3.59	
number of children	2.16		0.83	
1[married]	0.83		0.37	
joint leisure	9.45		7.56	
minimum of parents' childcare	25.04		14.36	
parental consumption (€)	592.82		223.12	
child consumption (€)	75.88		52.75	
	sample			
# of household groups	36			
# of households in a group	avg. = 11.86 (st.d. = 3.07)			
household/year observations	398			

Notes: The table reports summary statistics (mean and standard deviation) in our estimation sample. All time and monetary amounts are weekly. Monetary amounts are expressed in 2012 prices; the monetary series are deflated using the Consumer Price Index available by Statistics Netherlands. 'university education or similar' refers to higher vocational or university education and does not include intermediate vocational education.

assuming homogeneity within them. We opt for the second approach as the longitudinal variation in wages over our 3-year period is rather limited.

We split our sample of 398 household/year observations into 36 groups of households, each one comprising a little less than 12 observations on average. We assign observations to groups given values in the following categories: year (for 2009, 2010, 2012), age of youngest child (for 0-5, 6-12), age of parents (for 25-34, 35-44, 45-60), and education of parents (2 values, cutoff at intermediate vocational education, i.e. similar to junior college in the US). In this way we allow heterogeneity to vary with time, as well as with children's age and parent's age and education.

Summary statistics. Table 3 presents summary statistics in our sample. On average the male spouse is 41 years old and has a 36% probability of being university educated. The female spouse is almost 39 years old and is 38% likely to be university educated. He works on average 32.86 hours within the *7 am* to *6 pm Monday* to *Friday* zone while she works approximately 20.47 hours. Outside this time window, he works on average 8.26 hours while she works a mere 3.13. A household has on average 2.16 children and spends €593 on parental consumption and €76 on child consumption per week. In the baseline implementation of the model, we assume that parental consumption is shared equally between parents (we find that this makes little difference to our results as opposed to treating parental consumption as purely public). We calculate the minimum of parents' reported childcare, i.e. $\min\{T_1, T_2\}$, and we find it equal to 25.04 hours.

5.2 Testing and recovery

Testing. Our empirical analysis starts with a formal comparison of different collective models with private and joint time use. The first model in the comparison is our notion of collective rationality (Definition 2, CR in short). This model makes a formal distinction between private and joint times, but the gains from joint time equal the sum of gains from private times in equilibrium. There is no forgone flexibility or forgone specialization. The most general model in this comparison is our notion of collective rationality with togetherness (Definition 3, T–CR in short). This model makes an explicit distinction between private and joint times, and moreover allows that the marginal gains from joint time exceed the sum of gains from (both spouses') private times in equilibrium. According to this model, household members weigh these gains against the costs of forgone flexibility and specialization. The test of T–CR is the only one that uses information on w_K and p_m. The wage premium p_m is computed on the basis of different markups because we do not observe the actual premium per household. We say that T–CR is satisfied if there exists at least one markup (50%, 25% or 0% of the regular wage) so that the corresponding wage premiums allow us to rationalize the underlying group of households. The most restrictive specification that we consider is a collective model that makes no distinction between private and joint time use. Welfare thus depends on individual total times only. We refer to this model as collective rationality with aggregate times, A–CR.

Table 4 reports the pass rates of these three specifications. The pass rate captures the proportion of groups whose behavior is fully consistent with the conditions under consideration. Notice that we apply this 'sharp' test to each group separately, thereby accounting for general forms of preference heterogeneity *between* groups. A–CR describes the behavior of only 6% of groups, or 19 households in total. CR describes the behavior of 25% of groups, or 87 households in total. Finally, T–CR is consistent with 69% of groups, that is 25 groups or 263 households in total.[26] This already indicates that joint time indeed generates gains over and above (the sum of) private times as household members incur the costs of forgone flexibility and forgone specialization.

[26] We start from a specific scenario in which either C_P is shared equally or parents have the same individual valuations for it. Without this restriction, C_P is a public good with unobserved Lindahl prices. For that case, we find pass rates of 31%, 31%, and 81% for A–CR, CR, and T–CR respectively.

Table 4 – Pass rates of collective rationality in various models

model	pass rate (max. 1.0)	number of groups (max. 36)	number of households (max. 398)
CR	0.25	9	87
T–CR	0.69	25	263
A–CR	0.06	2	19

Notes: The table reports the pass rates of collective rationality (CR), collective rationality with togetherness (T–CR), and collective rationality with aggregate times only (A–CR), as well as the associated number of household groups and households that are rational in each case.

Pass rates provide empirical support for our novel notion of T–CR. Next, we compute the discriminatory power and predictive success of our main specifications, focusing on CR and T–CR. *Power* is one minus the pass rate of random data. It therefore addresses the question whether models are sufficiently strong to reject consistency for random, simulated observations. The stronger the discriminatory power of a model, the more it should reject consistency of these random data. *Predictive success*, introduced by Selten (1991) and axiomatized by Beatty and Crawford (2011), summarizes pass rates and power. It is the sum of pass rates and power minus one. Predictive success therefore captures the degree to which a model describes the observed data better than the random data. It is expressed on a continuum from -1 to 1. A predictive success score of 1 indicates that 100% of the actual data pass the model while 100% of the random data violate the model. This is the best possible scenario. Vice versa, a predictive success score of -1 indicates that 100% of the actual data violate the model while 100% of the random data pass the model. Positive predictive success scores are desirable.

To compute power, we follow a procedure outlined by Bronars (1987), which is based on Becker (1962)'s notion of irrational behavior. We construct new data by drawing random time and consumption bundles given a household's income and wages. We test consistency of our groups with CR and T–CR, while replacing the groups' actual data with the newly generated random data. The results are in table 5. CR rejects, on average, consistency for close to 80% of groups. Although this may seem high, it should

Table 5 – Power and predictive success of collective rationality in various models

model	discriminatory power	predictive success
CR	0.80	0.05
T–CR	0.52	0.22

Notes: The table reports the mean power and predictive success of collective rationality (CR) and collective rationality with togetherness (T–CR). See main text for definitions.

be noted that CR describes the actual data only 5% better than the random data. We then compute discriminatory power associated with T–CR. Our model rejects consistency for 52% of groups. Although this index is only slightly better than half, it shows that T–CR describes the actual data 22% better than the random data. This provides empirical support for our model.

Table 5 presents mean power and predictive success among our 36 groups. We now shed light on the underlying distribution of power and predictive success. Indeed, we compute both measures for each group separately. The results in figure 4 confirm empirical support for T–CR. The distribution of predictive success without togetherness (dashed line) clearly has much more mass in the interval between −1 and 0. T–CR generally dominates CR, except at the very top of the predictive success distribution.

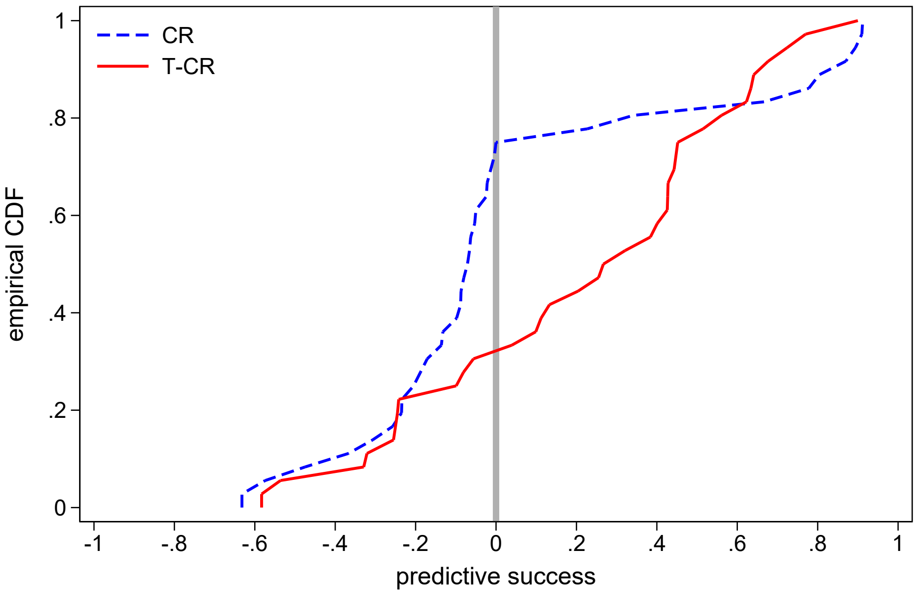

Figure 4 – Distribution of predictive success in various models

Notes: The figure plots the distribution of predictive success for collective rationality (CR) and collective rationality with togetherness (T–CR) among 36 groups of households. See main text for definitions.

Recovery of joint childcare. We found that T–CR improves the goodness-of-fit of the collective model without being overly permissive. Next, we use T–CR to separate private from joint childcare when only individual total childcare is available. Our main object of interest is the mean proportion $t_J/\min\{T_1, T_2\}$ within group; this reflects how much of the naive maximum amount of joint childcare is indeed supplied jointly. We apply the procedure described in section 4.3 to recover bounds on the mean within-group proportion of joint childcare needed to rationalize a given group of households.[27]

[27]In addition, we fix Δ at the lowest possible level per group of households that still allows us to collectively rationalize the households with togetherness. This minimizes heterogeneity in $t_J^{(v)}/\min\{T_1^{(v)}, T_2^{(v)}\}$ between households in the same group but may well increase heterogeneity in α between different groups of households as it makes our conditions stronger.

Table 6 – Distribution of bounds on mean proportion of joint childcare

mean $t_J/\min\{T_1, T_2\}$ within group	estimated lower bound	estimated upper bound
Distribution across groups:		
min	0	0.16
first quartile	0	0.75
median	0.13	0.94
mean	0.29	0.84
third quartile	0.68	1
max	0.99	1

Notes: The table reports the distribution *across groups* of the bounds on the mean *within-group* proportion of joint childcare, i.e. mean $t_J/\min\{T_1, T_2\}$ within group. The results are over 25 groups of households consistent with collective rationality with togetherness (T–CR).

Table 6 presents the distribution of bounds for all 25 groups consistent with T–CR. On average, joint childcare amounts to at least 29% and at most 84% of its naive maximum. However, there is large heterogeneity across groups. The maximum lower bound at 99% reflects there is a group in which households supply at least 99% of childcare jointly; the minimum upper bound at 16% suggests that households in another group supply at most 16% of childcare jointly. For a number of groups, the difference between lower and upper bounds is not more than one percentage point, indicating sharpness of our bounds. Finally, as our groups differ with respect to demographics (age of children, age and education of parents) we can investigate whether our bounds relate systematically to them. This is, however, hard to do in practice as, given we identify one set of bounds for each group of households, we only have 25 observations to assess a statistical hypothesis. Nevertheless, we observe that in groups where parents are better educated, the lower bound on joint childcare is weakly higher (further away from zero).

Next we turn to the levels of joint childcare translating the bounds on $t_J/\min\{T_1, T_2\}$

Table 7 – Distribution of bounds on joint childcare (weekly hours)

t_J	estimated lower bound	estimated upper bound	naive upper bound
Distribution across households:			
min	0	0	0
first quartile	0	5.00	5.29
median	0.42	9.75	10.41
mean	3.61	11.12	12.65
third quartile	5.14	15.11	17.02
max	34.75	51.49	51.49

Notes: The table reports the distribution *across households* of the bounds on joint childcare t_J. The results are over 263 households consistent with collective rationality with togetherness (T–CR).

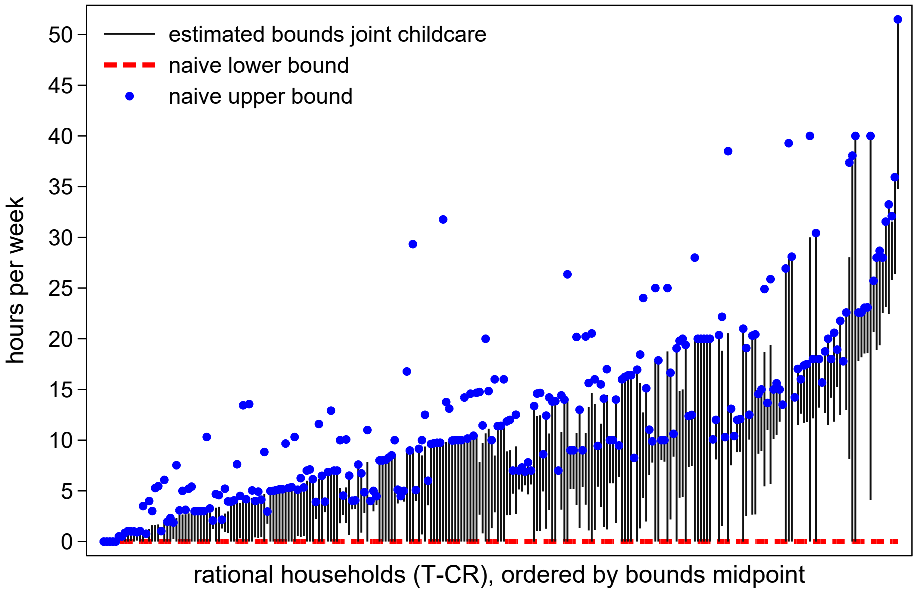

Figure 5 – Bounds on joint childcare

Notes: The figure plots the estimated bounds on joint childcare among 263 households consistent with collective rationality with togetherness (T–CR). The naive lower bound is zero; the naive upper bound is $\min\{T_1, T_2\}$.

to bounds on t_J itself. Given that each household has a different naive maximum childcare (the denominator), the bounds on t_J are mechanically household- rather than group-specific. Table 7 presents the distribution of bounds for all 263 households consistent with T–CR; figure 5 plots these bounds along with the naive minimum and maximum amounts per household. Two points are worth noting. First, joint childcare takes up a substantial amount of the overall supply of childcare in the household. While on average men spend 13.3 and women 21.7 hours with their children per week (raw data table 1), our average lower bound is 3.6 hours and our average upper bound is 11.1 hours. Second, figure 5 reveals that our approach produces informative and often sharp bounds for a large fraction of admissible households. These results together indicate that joint childcare -like joint leisure- is an important component of household time use.

5.3 The value of togetherness

We now have the necessary ingredients to identify the marginal value of joint leisure relative to private leisure ($\delta^{(v)}_{1,l_J} + \delta^{(v)}_{2,l_J} - \delta^{(v)}_{1,l_1} - \delta^{(v)}_{2,l_2}$) and the marginal value of joint childcare relative to private childcare ($\delta^{(v)}_{K,t_J} - \delta^{(v)}_{K,t_1} - \delta^{(v)}_{K,t_2}$). These values indicate how much the household is willing to pay for an hour of joint time *relative* to the price it pays for an hour of private time *by each spouse*. The T–CR model and its goodness-of-fit allow us to pin down *lower* bounds on both values. First, the model tells us that in equilibrium the value of joint leisure equals the wage premium for irregular work p_m, while the value of joint childcare equals the value of joint leisure plus the price of market childcare w_K. Second, the goodness-of-fit results from table 4 indicate which households behave

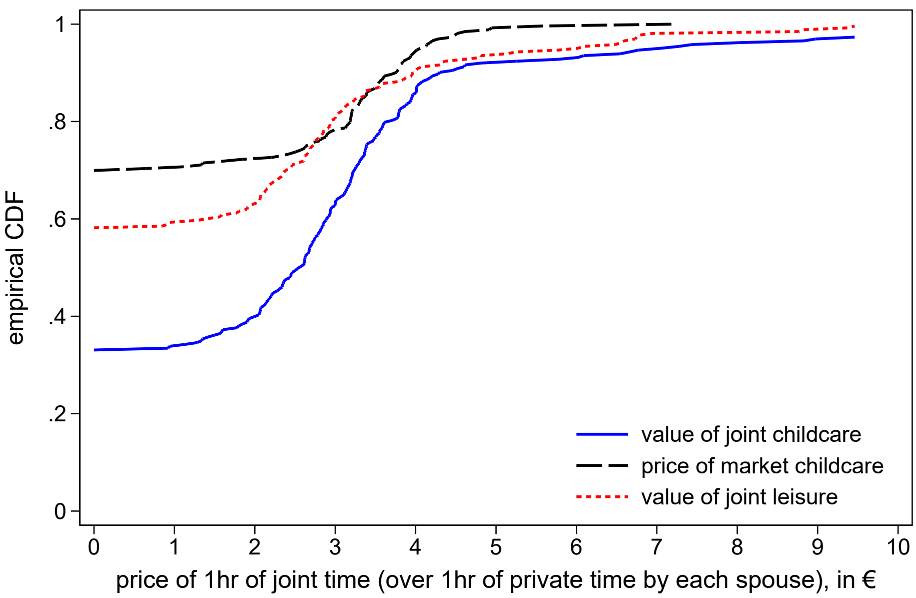

Figure 6 – Distribution of value of togetherness

Notes: The figure plots the distribution of the value of togetherness based on forgone specialization and forgone flexibility among 263 households consistent with collective rationality with togetherness (T–CR).

consistently with T–CR and which households do not. We found that 263 households are rationalizable with togetherness.

Figure 6 presents the results.[28] The dotted red line in Figure 6 presents the distribution of the underlying value of joint leisure across households. The mean value is €1.47, indicating that on average households are willing to pay €1.47 for an hour of joint leisure *over* the cost of an hour of private leisure by *each* spouse. This corresponds to 12.5% of the average wage in our sample. We see that 5% of households are willing to pay more than €6/hour to replace one hour of private leisure by each spouse with one hour of joint leisure.

The solid blue line represents the distribution of the value of joint childcare across households. Values lie mostly between €0 and €10 per hour of joint time, with a few outliers close to €20. The mean value is €2.49, indicating that on average households are willing to pay €2.49 for an hour of joint childcare *over* the cost of an hour of private childcare by *each* spouse. This corresponds to 20% of the average wage in our sample. Digging a bit deeper into the distribution, we see that 5% of households are willing to pay more than €7/hour. By contrast, for about 33% of households the willingness to pay for joint childcare is 0. This corresponds to households that are also consistent with CR.

These results provide us with a decomposition of the value of joint childcare in terms of

[28]To obtain these values we run a 2–dimensional grid search over the wage premium markup at 50%, 25%, and 0% (first dimension) and the price of market childcare at 0 (considering that parents may have access to costless informal childcare, eg. grandparents) or 33% of the lowest salary in the household (second dimension). We then select the combination of p_m and w_K that yields the *smallest* value for togetherness within a given group. We thus only identify lower bounds on the value of joint time.

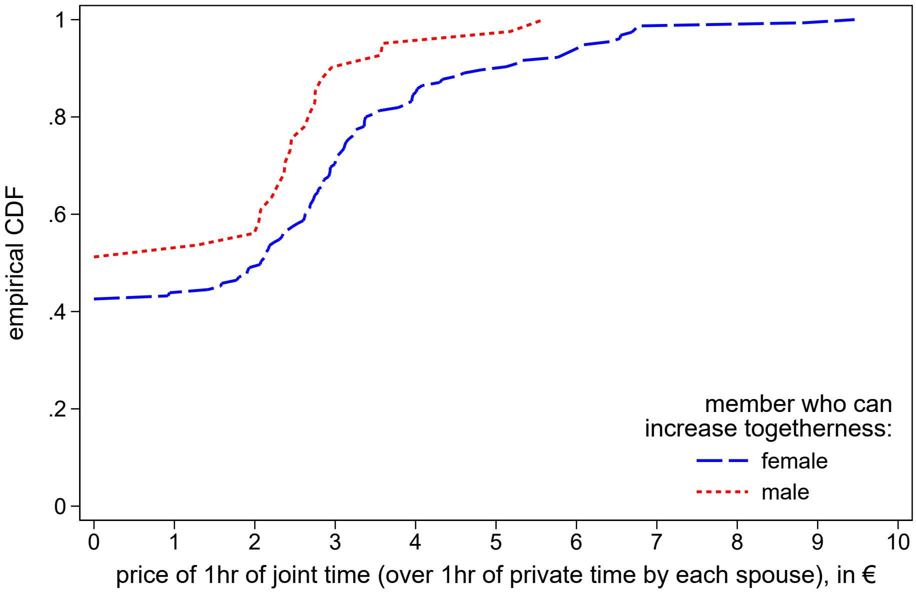

Figure 7 – Distribution of value of togetherness (forgone flexibility only)

Notes: The figure plots the distribution of the value of togetherness based on forgone flexibility among 196 households consistent with collective rationality with togetherness (T–CR) and $w_K = 0$.

the price of irregular work (forgone flexibility) and the price of market childcare (forgone specialization). The former also corresponds to the marginal value of joint leisure. Values for joint childcare equal to the price of market childcare indicate forgone specialization but no forgone flexibility in the household. Values for joint childcare equal to the value of joint leisure alone indicate forgone flexibility but no forgone specialization. The dashed black, resp. dotted red, lines in figure 6 plot the distribution of these components. The value of joint childcare frequently comprises both items and we cannot exclude either as a possible cost of togetherness.

Joint time and work schedules. As a final exercise, we study the interaction between the demand for joint time and the spouses' work schedule. We shut down forgone specialization (assuming for a moment that the household has free access to external childcare) and restrict attention to forgone flexibility (5).[29] Here we put forward the idea that one household member forgoes a wage premium in order to increase the amount of joint time in the household.

The individual who supplies less labor during regular hours has the opportunity to increase togetherness at cost p_m instead of $w_m + p_m$. The reason is simple: she can increase togetherness without working less hours in total; she can simply replace one hour of irregular with one hour of regular work. The latter does not put pressure on togetherness given the overlap in partners' regular work. Her husband cannot do this as any increase in his regular work immediately implies a drop in the maximum potential

[29]Note that 53% of groups in our sample (196 households) are consistent with T–CR and with $w_K = 0$.

amount of togetherness. About 80% of rational households in our sample have $h_1^R > h_2^R$, now assigning member 1 to men and member 2 to women. This implies that women are more frequently in the position where it is relatively cheaper to increase togetherness at cost p_m only. Then *more* women than men have an incentive to work at lower-paid moments, thus possibly compressing their hourly earnings.

In addition, a positive correlation between the value of togetherness and the likelihood of $h_1^R > h_2^R$ may compress female irregular hours even further. Figure 7 plots the distribution of the value of joint time separately for households in which women forgo earnings ($h_1^R > h_2^R$, dashed blue line) and for households in which men forgo earnings ($h_1^R \leq h_2^R$, dotted red line). The value of joint time is higher in those households where the female is the member with the less costly opportunity to increase joint time.[30] In particular, the added value of joint time is €0/hour for the median household with $h_1^R \leq h_2^R$ whereas it is slightly more than €2/hour for the median household with $h_1^R > h_2^R$.

On average, therefore, women have stronger incentives to move away from irregular work -and miss out on the wage premium- compared to men. This result provides a partial explanation for the gender wage gap. Women in our sample face stronger incentives than men to give up their better paid irregular or flexible work, therefore suppressing their hourly wages compared to men. Women's lack of flexibility at work is an explanation for the gender wage gap also suggested by Goldin (2014), Olivetti and Petrongolo (2016) and Cubas et al. (2018), and which our model fully supports. It does so by micro-founding the loss of flexibility at work through the demand for togetherness along with *women* optimally sacrificing irregular work for the sake of togetherness.

6 Conclusion

Spending time together with a partner is a major source of gain from marriage. However, models of household time use typically treat time as a commodity consumed by household members privately rather than also jointly. As a result, we know very little about how households value togetherness, what benefits and costs it accrues, or how it interacts with other time uses. Addressing these points has been this paper's main goal.

We extend the classical collective model to include togetherness in the form of joint leisure and joint childcare. Togetherness naturally requires that spouses synchronize their work schedules so as to be physically together at the same time. We have kept our analysis nonparametric providing the first nonparametric characterization and empirical implementation of togetherness.

Based on revealed preferences conditions, we show that our model provides a substantially better fit to the data compared to the classical model. Similar conditions allow us

[30] In particular, households with $h_1^R > h_2^R$ are more likely to face a binding upper bound on togetherness and thus forgo p_2.

to obtain bounds on joint leisure and, separately, joint childcare - both rarely observed in the data. In practice, we estimate bounds only on the latter as our data actually report joint leisure. Our bounds unequivocally suggest that parents engage in joint childcare. Moreover, we estimate the value that togetherness accrues to households and we find it substantial: households pay on average 20% of a spouse's wage to convert an hour of childcare from private to joint. The similar figure for leisure stands at 12.5% of the wage.

Seen together, our results suggest that togetherness is an important component of household time use despite it being relatively overlooked in the literature. This implies that modern policies aiming for example at work-life balance should not neglect togetherness as part of that balance. Our model offers a few simple policy instruments, such as the wage premium for certain types of work or the cost of market childcare. The core of our policy argument, however, is that togetherness comes along with certain costs -we call them forgone flexibility and forgone specialization- which likely accrue differently to men and women in the household. Any policy interested in togetherness should therefore closely look into those costs.

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Appendices

A Data appendix

The main data we use come from the Longitudinal Internet Studies for the Social sciences in the Netherlands (CentERdata, 2012). The LISS consists of different studies, each with its own data covering a given topic. We combine data from the (1.) *Household Box* for baseline demographics and income, (2.) *Core Study 5 Family and Household* for household composition, the presence and age of children etc., (3.) *Core Study 6 Work and Schooling* for working hours and timing of work, and (4.) *Assembled Study 34 Time Use and Consumption* for consumption and time use. The latter module, which provides the bulk of our data, is described in detail in Cherchye et al. (2012).

We draw data from three waves, covering calendar years 2009, 2010, and 2012. Although the LISS is running continuously since late 2007, it is only in those three years that we can obtain consistent consumption and time use data. Our sample consists of 398 household×year observations on households with children up to 12 years old and in which both spouses participate in the labor market. We construct this sample as follows:

1. Within our time frame, we select households where two spouses are present.

2. We drop those who experience marital status changes within a given year as their behavior may be constrained by such changes. We also drop those with inconsistent information on gender and year of birth, homosexual couples, as well as couples where both spouses declare themselves as household heads (this makes hard to assign information subsequently).

3. We require that a household has completed the Household Box and all studies mentioned above; in this case, we merge data per household across studies. Up to this point, our simple selection criteria result in approximately 3130 household×year observations, already a fraction of the approximately 10200 household×year observations before any selection (the last number counts unique households in *Core Study 5 Family and Household* in years 2009, 2010, and 2012).

4. Both spouses must be between 25-60 years old (we do not want time use to be restricted by statutory retirement or schooling) and participate in the labor market. The latter severely restricts our sample to 1410 household×year observations.

5. Households must have at least one child up to 12 years old. This leaves us with 477 representing another large, but inevitable given our focus, sample cut.

6. Finally, we require that the age and gender of children is reported consistently, that

parents have non-missing childcare, and that consumption is not missing or zero. Our final sample has 398 household×year observations.

Further we define the main variables we use throughout the paper. *Joint leisure* is the leisure time that spouses spend together with one another. Both spouses report this (e.g. variables `bf09a064-65` in wave 2009). The difference in spouses' response to this is in most cases negligible/small; there are some households, however, where the difference is large but seemingly unrelated to household characteristics or other time use variables. We opted for using the minimum of the spouses' respective responses as this is the only choice that guarantees non-negative private leisure. *Private leisure* is the difference between individual total leisure and joint leisure, which we construct ourselves. *Individual total leisure* is the time that each spouse spends on leisure activities (e.g. variables `bf09a021-22` in wave 2009).

Individual total childcare is the time each spouse spends on activities with children (e.g. variables `bf09a013-14` in wave 2009).

Market work is the time each spouse spends working for pay on the market, including the time on a second job (if any). These are variables `cw09b127` for the main job and `cw09b144` for a second job from Core Study 6. We impose a theoretical maximum of 84 weekly market hours (12 hours per day × 7 days per week). We split market work into regular and irregular hours according to the rule described in section 5.1; to implement this, we use indicator variables for how often one works irregular hours (e.g. variable `cw09b425` in wave 2009).

We require that the weekly time budget of each spouse adds up to 168 hours. To confirm this we use information on the many time uses recorded in Assembled Study 34. Interestingly, the vast majority of households have their time uses add up to exactly (or very near) 168 hours; for the rest we make a normalization ourselves.

Hourly wages are calculated as monthly earnings over monthly hours of market work. *Monthly earnings* is the personal net monthly income (variable `nettoink_f`), which, unless directly reported by the individual, it is imputed in the LISS based on gross income.

Parental consumption is the raw sum of expenditure on various goods, net of goods for children. These include food (at home or away), excluding food of children, tobacco products, clothing, personal care products and services, medical costs, leisure activities costs, costs of further schooling, donations and gifts, rent, household utilities, transport costs, insurance costs, alimony and financial support for children not living at home, costs of debts and loans, and home maintenance costs (e.g. variables `bf09a066-70`, `bf09a072-77`, `bf09a095-103` in wave 2009). Several of those items (those considered public expenditure) are reported by both spouses. The responses are surprisingly close. We opt for using the female responses as they include slightly fewer zeros. We drop one household where husband-wife responses differ by orders of magnitude.

Child consumption is the raw sum of expenditure on goods for children. These include food (at home or away), clothing, personal care products and services, medical costs, leisure activities costs, costs of schooling, and gifts and presents (e.g. variables `bf09a093`, `bf09a105-113` in wave 2009). We impute child consumption for four households for which it is missing. The imputation is statistical: we regress C_K (non-missing in the majority of households) on a large array of demographics, work hours, and parents' consumption, and we predict it for the households for which it is missing.

B Model appendix

B.1 Upper limit on joint time

Here we show how we obtain condition (5) in the main text. Let $\mathcal{T}_m$ be the total amount of time after sleep and personal care. If this is different between spouses, the applicable $\mathcal{T}_m$ is the lowest between the two. Togetherness cannot be larger than this, therefore $l_J + t_J \leq \mathcal{T}_m$. The spouses, however, work privately on the market, so their available right hand side time is actually even lower. So we need to subtract the amount of time they are at work. If there is no irregular work, we subtract the *maximum* of the spouse's regular hours as we have assumed these hours always overlap. The spouse who works for longer limits maximum togetherness, therefore $l_J + t_J \leq \mathcal{T}_m - \max\left\{h_1^R, h_2^R\right\}$. If there is irregular work, we further subtract the total amount of such work by *either* spouse as we have assumed irregular hours never overlap. This gives us

$$l_J + t_J \leq \mathcal{T}_m - \max\left\{h_1^R, h_2^R\right\} - h_1^I - h_2^I$$

which is condition (5) in the main text. Note that we could, in principle, tighten this further by also introducing private leisure and private childcare. This would require assumptions on the joint timing of these activities, i.e. which of these private activities may overlap between spouses and to which extent. We refrain from making such assumptions as, unlike market work, there is little empirical guidance on this issue.

B.2 Proof of Proposition 1

Since Proposition 1 is a special case of Proposition 2, we do not repeat the full proof here. We refer the reader to appendix B.3 for the full proof; here we focus on the implication that if $\tilde{S}_K$ satisfies $GARP$, then S_K also satisfies $GARP$.

Let $\tilde{S}_K = \{\delta_{K,t_1}^{(v)},\ \delta_{K,t_2}^{(v)},\ \delta_{K,t_J}^{(v)},\ 1;\ t_1^{(v)},\ t_2^{(v)},\ t_J^{(v)},\ C_K^{(v)}\}_{v\in V}$ with $\delta_{K,t_m}^{(v)} = w_m^{(v)}$ and $\delta_{K,t_J}^{(v)} = w_1^{(v)} + w_2^{(v)}$; and let $S_K = \{w_1^{(v)},\ w_2^{(v)},\ 1;\ T_1^{(v)},\ T_2^{(v)},\ C_K^{(v)}\}_{v\in V}$. Then

$$\delta_{K,t_1}^{(v)}(t_1^{(s)} - t_1^{(v)}) + \delta_{K,t_2}^{(v)}(t_2^{(s)} - t_2^{(v)}) + \delta_{K,t_J}^{(v)}(t_J^{(s)} - t_J^{(v)}) + (C_K^{(s)} - C_K^{(v)}) \leq 0$$

$$\Leftrightarrow w_1^{(v)}(t_1^{(s)} - t_1^{(v)}) + w_2^{(v)}(t_2^{(s)} - t_2^{(v)}) + (w_1^{(v)} + w_2^{(v)})(t_J^{(s)} - t_J^{(v)}) + (C_K^{(s)} - C_K^{(v)}) \leq 0$$
$$\Leftrightarrow w_1^{(v)}(T_1^{(s)} - T_1^{(v)}) + w_2^{(v)}(T_2^{(s)} - T_2^{(v)}) + (C_K^{(s)} - C_K^{(v)}) \leq 0.$$

To obtain the second line, we use that $\delta_{K,t_m}^{(v)} = w_m^{(v)}$ and $\delta_{K,t_J}^{(v)} = w_1^{(v)} + w_2^{(v)}$. To obtain the third line, we use that $t_1^{(v)} + t_J^{(v)} = T_1^{(v)}$ and $t_2^{(v)} + t_J^{(v)} = T_2^{(v)}$. Summarizing, any revealed preference relation that exists for $\tilde{S}_K$ exists also for S_K, and vice versa. We may therefore conclude that $\tilde{S}_K$ satisfies $GARP$ if and only if S_K satisfies $GARP$.

As a final remark, we note that the second line still holds if we allow for corners. Suppose that $t_J^{(v)} = 0$ and thus $\delta_{K,t_J}^{(v)} \leq w_1^{(v)} + w_2^{(v)}$. First, a rationalization with $\delta_{K,t_J}^{(v)} = w_1^{(v)} + w_2^{(v)}$ (trivially) implies that there also exists a value $\delta_{K,t_J}^{(v)} \leq w_1^{(v)} + w_2^{(v)}$ that rationalizes the data. The other implication follows from

$$w_1^{(v)}(t_1^{(s)} - t_1^{(v)}) + w_2^{(v)}(t_2^{(s)} - t_2^{(v)}) + (w_1^{(v)} + w_2^{(v)})(t_J^{(s)} - 0) + (C_K^{(s)} - C_K^{(v)}) \leq 0$$
$$\Rightarrow \delta_{K,t_1}^{(v)}(t_1^{(s)} - t_1^{(v)}) + \delta_{K,t_2}^{(v)}(t_2^{(s)} - t_2^{(v)}) + \delta_{K,t_J}^{(v)}(t_J^{(s)} - 0) + (C_K^{(s)} - C_K^{(v)}) \leq 0.$$

B.3 Proof of Proposition 2

In the first part of the proof ((1) $\Rightarrow$ (2)), we use that a necessary condition for consistency with a convex problem is that the Karush-Kuhn-Tucker conditions hold. Assuming continuity and concavity of U_m and U_K we replace the partial derivatives of the utility functions with suitable super-gradients to obtain

$$u_m^{(s)} - u_m^{(v)} \leq \eta_m^{(v)} \left[\delta_{m,l_m}^{(v)}(l_m^{(s)} - l_m^{(v)}) + \delta_{m,l_J}^{(v)}(l_J^{(s)} - l_J^{(v)}) + \delta_{m,C_P}^{(v)}(C_P^{(s)} - C_P^{(v)})\right]$$
$$u_K^{(s)} - u_K^{(v)} \leq \eta_K^{(v)} \left[\delta_{K,t_1}^{(v)}(t_1^{(s)} - t_1^{(v)}) + \delta_{K,t_2}^{(v)}(t_2^{(s)} - t_2^{(v)}) + \delta_{K,t_J}^{(v)}(t_J^{(s)} - t_J^{(v)}) + (C_K^{(s)} - C_K^{(v)})\right],$$

with $\eta_m^{(v)} = \lambda^{(v)}/\mu_m^{(v)}$ and $\eta_K^{(v)} = \lambda^{(v)}/\mu_K^{(v)}$. Finally, given that $\{\delta_{m,l_m}^{(v)}, \delta_{m,l_J}^{(v)}, \delta_{m,C_P}^{(v)}\}$ and $\{\delta_{K,t_1}^{(v)}, \delta_{K,t_2}^{(v)}, \delta_{K,t_J}^{(v)}, 1\}$ act as prices in the above Afriat-like inequalities, and $\{l_m^{(v)}, l_J^{(v)}, C_P^{(v)}\}$ and $\{t_1^{(v)}, t_2^{(v)}, t_J^{(v)}, C_K^{(v)}\}$ as quantities, we can reformulate these conditions in terms of consistency of $\{\delta_{m,l_m}^{(v)}, \delta_{m,l_J}^{(v)}, \delta_{m,C_P}^{(v)}; l_m^{(v)}, l_J^{(v)}, C_P^{(v)}\}_{v\in V}$ and $\{\delta_{K,t_1}^{(v)}, \delta_{K,t_2}^{(v)}, \delta_{K,t_J}^{(v)}, 1; t_1^{(v)}, t_2^{(v)}, t_J^{(v)}, C_K^{(v)}\}_{v\in V}$ with GARP (Varian, 1982).

In the second part of the proof ((2) $\Rightarrow$ (1)), we have to show that there exist weights $\mu_1^{(v)}$ and $\mu_2^{(v)}$, utility functions U_1, U_2 and U_K that rationalize the data with togetherness, provided that the conditions in Proposition 2 hold. To this end, we first construct the utility functions. Let

$$U_m(l_m, l_J, C_P) = \min_{(s)} u_m^{(s)} + \eta_m^{(s)} \left(\delta_{m,l_m}^{(s)}(l_m - l_m^{(s)}) + \delta_{m,l_J}^{(s)}(l_J - l_J^{(s)}) + \delta_{m,C_P}^{(s)}(C_P - C_P^{(s)})\right)$$
$$U_K(t_1, t_2, t_J, C_K) = \min_{(s)} u_K^{(s)} + \eta_K^{(s)} \left(\delta_{K,t_1}^{(s)}(t_1 - t_1^{(s)}) + \delta_{K,t_2}^{(s)}(t_2 - t_2^{(s)}) + \delta_{K,t_J}^{(s)}(t_J - t_J^{(s)}) + (C_K - C_K^{(s)})\right).$$

One can verify that these piecewise linear functions are nonsatiated, continuous and concave. After all, the minimum of concave functions is concave. One can also show that $U_1(l_1^{(v)}, l_J^{(v)}, C_P^{(v)}) = u_1^{(v)}$. By definition of U_1:

$$U_1(l_1, l_J, C_P) = \min_{(s)} u_1^{(s)} + \eta_1^{(s)} \left(\delta_{1,l_1}^{(s)}(l_1 - l_1^{(s)}) + \delta_{1,l_J}^{(s)}(l_J - l_J^{(s)}) + \delta_{1,C_P}^{(s)}(C_P - C_P^{(s)}) \right).$$

This implies $U_1(l_1^{(v)}, l_J^{(v)}, C_P^{(v)}) \leq u_1^{(v)}$. We cannot have that $U_1(l_1^{(v)}, l_J^{(v)}, C_P^{(v)}) < u_1^{(v)}$ because this violates the Afriat inequalities. Suppose that $U_1(l_1^{(v)}, l_J^{(v)}, C_P^{(v)})$ is at its minimum in situation r, i.e.

$$U_1(l_1^{(v)}, l_J^{(v)}, C_P^{(v)}) = u_1^{(r)} + \eta_1^{(r)} \Big(\delta_{1,l_1}^{(r)}(l_1^{(v)} - l_1^{(r)}) + \delta_{1,l_J}^{(r)}(l_J^{(v)} - l_J^{(r)}) + \delta_{1,C_P}^{(r)}(C_P^{(v)} - C_P^{(r)}) \Big).$$

Then $u_1^{(v)} > U_1(l_1^{(v)}, l_J^{(v)}, C_P^{(v)})$ implies

$$u_1^{(v)} > u_1^{(r)} + \eta_1^{(r)} \Big(\delta_{1,l_1}^{(r)}(l_1^{(v)} - l_1^{(r)}) + \delta_{1,l_J}^{(r)}(l_J^{(v)} - l_J^{(r)}) + \delta_{1,C_P}^{(r)}(C_P^{(v)} - C_P^{(r)}) \Big),$$

a contradiction of the Afriat inequalities implied by Proposition 2. This shows that $U_1(l_1^{(v)}, l_J^{(v)}, C_P^{(v)}) = u_1^{(v)}$. A similar reasoning gives that $U_2(l_2^{(v)}, l_J^{(v)}, C_P^{(v)}) = u_2^{(v)}$ and $U_K(t_1^{(v)}, t_2^{(v)}, t_J^{(v)}, C_K^{(v)}) = u_K^{(v)}$.

Second, we need to show that the data under consideration maximize the constructed utility functions. In other words, for any $l_m, l_J, h_m^R, h_m^I, t_m, t_J, T_K, C_P, C_K$ that satisfy

- $C_P + C_K + w_K^{(v)} T_K - \sum_{m=1}^2 (w_m^{(v)} h_m^R + (w_m^{(v)} + p_m^{(v)}) h_m^I) \leq C_P^{(v)} + C_K^{(v)} + w_K^{(v)} T_K^{(v)} - \sum_{m=1}^2 (w_m^{(v)} h_m^{R\,(v)} + (w_m^{(v)} + p_m^{(v)}) h_m^{I\,(v)})$;
- $l_m + l_J + t_m + t_J + h_m^R + h_m^I = l_m^{(v)} + l_J^{(v)} + t_m^{(v)} + t_J^{(v)} + h_m^{R\,(v)} + h_m^{I\,(v)}$;
- $U_K(t_1, t_2, t_J, C_K) \geq U_K(t_1^{(v)}, t_2^{(v)}, t_J^{(v)}, C_K^{(v)})$;
- $\sum_{m=1}^2 t_m + t_J + T_K = \sum_{m=1}^2 t_m^{(v)} + t_J^{(v)} + T_K^{(v)}$; and
- $l_J + t_J + \max\{h_1^R, h_2^R\} + h_1^I + h_2^I \leq l_J^{(v)} + t_J^{(v)} + \max\{h_1^{R(v)}, h_2^{R(v)}\} + h_1^{I(v)} + h_2^{I(v)}$,

it must be the case that $\mu_1^{(v)} U_1(l_1, l_J, C_P) + \mu_2^{(v)} U_2(l_2, l_J, C_P) \leq \mu_1^{(v)} U_1(l_1^{(v)}, l_J^{(v)}, C_P^{(v)}) + \mu_2^{(v)} U_2(l_2^{(v)}, l_J^{(v)}, C_P^{(v)})$. Supplementary to our construction of utility functions, we also choose $\mu_1^{(v)} = 1/\eta_1^{(v)}$ and $\mu_2^{(v)} = 1/\eta_2^{(v)}$. Thus

$$\begin{aligned}
&\mu_1^{(v)} U_1(l_1, l_J, C_P) + \mu_2^{(v)} U_2(l_2, l_J, C_P) \\
\leq &\mu_1^{(v)} u_1^{(v)} + \mu_2^{(v)} u_2^{(v)} + \sum_m \left(\delta_{m,l_m}^{(v)}(l_m - l_m^{(v)}) + \delta_{m,l_J}^{(v)}(l_J - l_J^{(v)}) + \delta_{m,C_P}^{(v)}(C_P - C_P^{(v)}) \right) \\
= &\mu_1^{(v)} u_1^{(v)} + \mu_2^{(v)} u_2^{(v)} + (C_P - C_P^{(v)}) + (w_1^{(v)} - p_2^{(v)})(l_1 - l_1^{(v)}) \\
&\quad + w_2^{(v)}(l_2 - l_2^{(v)}) + (w_1^{(v)} + w_2^{(v)})(l_J - l_J^{(v)}) \\
= &\mu_1^{(v)} u_1^{(v)} + \mu_2^{(v)} u_2^{(v)} + (C_P - C_P^{(v)}) + w_1^{(v)}(L_1 - L_1^{(v)}) + w_2^{(v)}(L_2 - L_2^{(v)}) + p_2^{(v)}(l_1^{(v)} - l_1)
\end{aligned}$$

$$
\begin{aligned}
\le&\mu_1^{(v)}u_1^{(v)} + \mu_2^{(v)}u_2^{(v)} + (C_P - C_P^{(v)}) + w_1^{(v)}(L_1 - L_1^{(v)}) + w_2^{(v)}(L_2 - L_2^{(v)})\\
&+ p_2^{(v)}(H_1^{(v)} + h_2^{I(v)} + t_J^{(v)} + L_1^{(v)} - H_1 - h_2^I - t_J - L_1)\\
=&\mu_1^{(v)}u_1^{(v)} + \mu_2^{(v)}u_2^{(v)} + (C_P - C_P^{(v)}) + w_1^{(v)}(L_1 - L_1^{(v)}) + w_2^{(v)}(L_2 - L_2^{(v)})\\
&+ p_2^{(v)}(h_2^{I(v)} - h_2^I) + p_2{}^{(v)}(t_1 - t_1^{(v)})\\
\le&\mu_1^{(v)}u_1^{(v)} + \mu_2^{(v)}u_2^{(v)} + (C_P - C_P^{(v)}) + w_1^{(v)}(L_1 - L_1^{(v)}) + w_2^{(v)}(L_2 - L_2^{(v)})\\
&+ p_2^{(v)}(h_2^{I(v)} - h_2^I) + (C_K - C_K^{(v)}) + w_K^{(v)}(T_K - T_K^{(v)}) + w_1^{(v)}(T_1 - T_1^{(v)}) + w_2^{(v)}(T_2 - T_2^{(v)})\\
=&\mu_1^{(v)}u_1^{(v)} + \mu_2^{(v)}u_2^{(v)} + (C_P - C_P^{(v)}) + (C_K - C_K^{(v)}) + w_K^{(v)}(T_K - T_K^{(v)})\\
&+ w_1^{(v)}(H_1^{(v)} - H_1) + w_2^{(v)}(H_2^{(v)} - H_2) + p_2^{(v)}(h_2^{I(v)} - h_2^I)\\
\le&\mu_1^{(v)}u_1^{(v)} + \mu_2^{(v)}u_2^{(v)}.
\end{aligned}
$$

Thus it follows that $\mu_1^{(v)}u_1^{(v)} + \mu_2^{(v)}u_2^{(v)} = \mu_1^{(v)}U_1(l_1^{(v)}, l_J^{(v)}, C_P^{(v)}) + \mu_2^{(v)}U_2(l_2^{(v)}, l_J^{(v)}, C_P^{(v)})$. The first inequality follows by construction of U_1 and U_2. The first equality replaces our shadow prices with wages and premiums. This follows from the conditions of Proposition 2. The second and third inequalities follow from Lemmas 1 and 2 below. The third and fourth equalities stem from the time budgets and identities while the fourth inequality is due to the budget constraint.

For each bundle $l_m, l_J, h_m^R, h_m^I, t_m, t_J, T_K, C_P, C_K$ that respects the budget constraint, the parental time constraints, the child well-being constraint, the childcare constraint and the upper bound on joint time use, we have shown that

$$
\mu_1^{(v)}U_1(l_1, l_J, C_P) + \mu_2^{(v)}U_2(l_2, l_J, C_P) \le \mu_1^{(v)}U_1(l_1^{(v)}, l_J^{(v)}, C_P^{(v)}) + \mu_2^{(v)}U_2(l_2^{(v)}, l_J^{(v)}, C_P^{(v)}).
$$

We conclude that the constructed weights $\mu_1^{(v)}$, $\mu_2^{(v)}$ and utility functions U_1, U_2 and U_K effectively provide a *collective rationalization with togetherness*.

Lemma 1 We show that $l_1^{(v)} - l_1 \le (h_2^{I(v)} - h_2^I) + (H_1^{(v)} - H_1) + (t_J^{(v)} - t_J) + (L_1^{(v)} - L_1)$.
Proof. We start from the upper bound on joint time use. The second implication follows from convexity of the maximum operator and our assumption that $h_1^{R(v)} > h_2^{R(v)}$, which effectively implies that $\max\{h_1^R, h_2^R\} - \max\{h_1^{R(v)}, h_2^{R(v)}\} \ge (h_1^R - h_1^{R(v)})$. Then:

$$
\begin{aligned}
&l_J + t_J + \max\{h_1^R, h_2^R\} + h_1^I + h_2^I \le l_J^{(v)} + t_J^{(v)} + \max\{h_1^{R(v)}, h_2^{R(v)}\} + h_1^{I(v)} + h_2^{I(v)}\\
&\Rightarrow \max\{h_1^R, h_2^R\} - \max\{h_1^{R(v)}, h_2^{R(v)}\} + (h_1^I - h_1^{I(v)}) + (h_2^I - h_2^{I(v)}) \le l_J^{(v)} - l_J + t_J^{(v)} - t_J\\
&\Rightarrow (h_1^R - h_1^{R(v)}) + (h_1^I - h_1^{I(v)}) + (h_2^I - h_2^{I(v)}) \le l_J^{(v)} - l_J + t_J^{(v)} - t_J\\
&\Rightarrow l_J - l_J^{(v)} \le (h_2^{I(v)} - h_2^I) + (H_1^{(v)} - H_1) - (t_J - t_J^{(v)})\\
&\Rightarrow l_1^{(v)} - l_1 \le (h_2^{I(v)} - h_2^I) + (H_1^{(v)} - H_1) - (t_J - t_J^{(v)}) + (L_1^{(v)} - L_1).
\end{aligned}
$$

■

Lemma 2 We show that

$$p_2^{(v)}(t_1 - t_1^{(v)}) \le w_1^{(v)}(T_1 - T_1^{(v)}) + w_2^{(v)}(T_2 - T_2^{(v)}) + (C_K - C_K^{(v)}) + w_K^{(v)}(T_K - T_K^{(v)}).$$

Proof. We start from our construction of function $U_K(t_1, t_2, t_J, C_K)$:

$$U_K(t_1, t_2, t_J, C_K) \le u_K^{(v)} + \eta_K^{(v)} \left(\delta_{K,t_1}^{(v)}(t_1 - t_1^{(v)}) + \delta_{K,t_2}^{(v)}(t_2 - t_2^{(v)}) + \delta_{K,t_J}^{(v)}(t_J - t_J^{(v)}) + (C_K - C_K^{(v)}) \right).$$

Moreover, t_1, t_2, t_J, C_K must satisfy $U_K(t_1, t_2, t_J, C_K) \ge u_K^{(v)}$ and hence

$$\begin{aligned}
& u_K^{(v)} + \eta_K^{(v)} \left(\delta_{K,t_1}^{(v)}(t_1 - t_1^{(v)}) + \delta_{K,t_2}^{(v)}(t_2 - t_2^{(v)}) + \delta_{K,t_J}^{(v)}(t_J - t_J^{(v)}) + (C_K - C_K^{(v)}) \right) \ge u_K^{(v)} \\
& \Rightarrow \delta_{K,t_1}^{(v)}(t_1 - t_1^{(v)}) + \delta_{K,t_2}^{(v)}(t_2 - t_2^{(v)}) + \delta_{K,t_J}^{(v)}(t_J - t_J^{(v)}) + (C_K - C_K^{(v)}) \ge 0 \\
& \Rightarrow (w_1^{(v)} - p_2^{(v)} - w_K^{(v)})(t_1 - t_1^{(v)}) + (w_2^{(v)} - w_K^{(v)})(t_2 - t_2^{(v)}) + (C_K - C_K^{(v)}) \\
& \quad + (w_1^{(v)} + w_2^{(v)} - w_K^{(v)})(t_J - t_J^{(v)}) \ge 0 \\
& \Rightarrow w_1^{(v)}(T_1 - T_1^{(v)}) + w_2^{(v)}(T_2 - T_2^{(v)}) + (C_K - C_K^{(v)}) \\
& \quad + w_K^{(v)}(T_1^{(v)} + t_2^{(v)} - T_1 - t_2) + p_2^{(v)}(t_1^{(v)} - t_1) \ge 0 \\
& \Rightarrow w_1^{(v)}(T_1 - T_1^{(v)}) + w_2^{(v)}(T_2 - T_2^{(v)}) + (C_K - C_K^{(v)}) + w_K^{(v)}(T_K - T_K^{(v)}) \ge p_2^{(v)}(t_1 - t_1^{(v)}).
\end{aligned}$$

■

B.4 Recovery of joint childcare: example

We note that a *collective rationalization with togetherness* requires consistency with Statements $(a)-(d)$ in Proposition 2. First, the GARP applied to $\tilde{S}_K = \{\delta_{K,t_1}^{(v)}, \delta_{K,t_2}^{(v)}, \delta_{K,t_J}^{(v)}, 1; t_1^{(v)}, t_2^{(v)}, t_J^{(v)}, C_K^{(v)}\}_{v \in \{A,B\}}$ imposes that either

$$\begin{aligned}
& \delta_{K,t_1}^{(A)}(t_1^{(A)} - t_1^{(B)}) + \delta_{K,t_2}^{(A)}(t_2^{(A)} - t_2^{(B)}) + \delta_{K,t_J}^{(A)}(t_J^{(A)} - t_J^{(B)}) + (C_K^{(A)} - C_K^{(B)}) \le 0 \\
& \Rightarrow (w_1^{(A)} - w_K^{(A)})(T_1^{(A)} - T_1^{(B)}) + (w_2^{(A)} - w_K^{(A)})(T_2^{(A)} - T_2^{(B)}) \\
& \quad + w_K^{(A)}(t_J^{(A)} - t_J^{(B)}) + (C_K^{(A)} - C_K^{(B)}) \le 0 \\
& \Rightarrow 17(10) + 3(t_J^{(A)} - t_J^{(B)}) - 125 \le 0 \quad \Rightarrow \quad t_J^{(A)} - t_J^{(B)} \le -15
\end{aligned}$$

or

$$\begin{aligned}
& \delta_{K,t_1}^{(B)}(t_1^{(B)} - t_1^{(A)}) + \delta_{K,t_2}^{(B)}(t_2^{(B)} - t_2^{(A)}) + \delta_{K,t_J}^{(B)}(t_J^{(B)} - t_J^{(A)}) + (C_K^{(B)} - C_K^{(A)}) \le 0 \\
& \Rightarrow (w_1^{(B)} - w_K^{(B)})(T_1^{(B)} - T_1^{(A)}) + (w_2^{(B)} - w_K^{(B)})(T_2^{(B)} - T_2^{(A)}) \\
& \quad + w_K^{(B)}(t_J^{(B)} - t_J^{(A)}) + (C_K^{(B)} - C_K^{(A)}) \le 0 \\
& \Rightarrow 7(-10) + 3(t_J^{(B)} - t_J^{(A)}) + 125 \le 0 \quad \Rightarrow \quad t_J^{(A)} - t_J^{(B)} \ge 55/3.
\end{aligned}$$

Otherwise GARP is violated and so are the conditions of Proposition 2. Second, we note that $t_J^{(A)} - t_J^{(B)} \leq -15$ is infeasible because $t_J^{(B)} \in [0, 10]$ and $t_J^{(A)} \geq 0$. The only possible conclusion is therefore $t_J^{(A)} - t_J^{(B)} \geq 18.33$.

Finally, choose $t_J^{(A)}$ and $t_J^{(B)}$ in order to minimize $t_J^{(A)}/20 + t_J^{(B)}/10$ subject to $t_J^{(A)} - t_J^{(B)} \geq 18.33$, $t_J^{(A)} \in [0, 20]$ and $t_J^{(B)} \in [0, 10]$. The result is $t_J^{(A)} = 18.33$ and $t_J^{(B)} = 0$, corresponding to a lower bound on the (mean) proportion of joint childcare among households A and B of 0.45833. Alternatively, choose $t_J^{(A)}$ and $t_J^{(B)}$ in order to maximize $t_J^{(A)}/20 + t_J^{(B)}/10$ subject to $t_J^{(A)} - t_J^{(B)} \geq 18.33$, $t_J^{(A)} \in [0, 20]$ and $t_J^{(B)} \in [0, 10]$. The result is $t_J^{(A)} = 20$ and $t_J^{(B)} = 1.67$, corresponding to an upper bound on the (mean) proportion of joint childcare among households A and B of 0.58333.